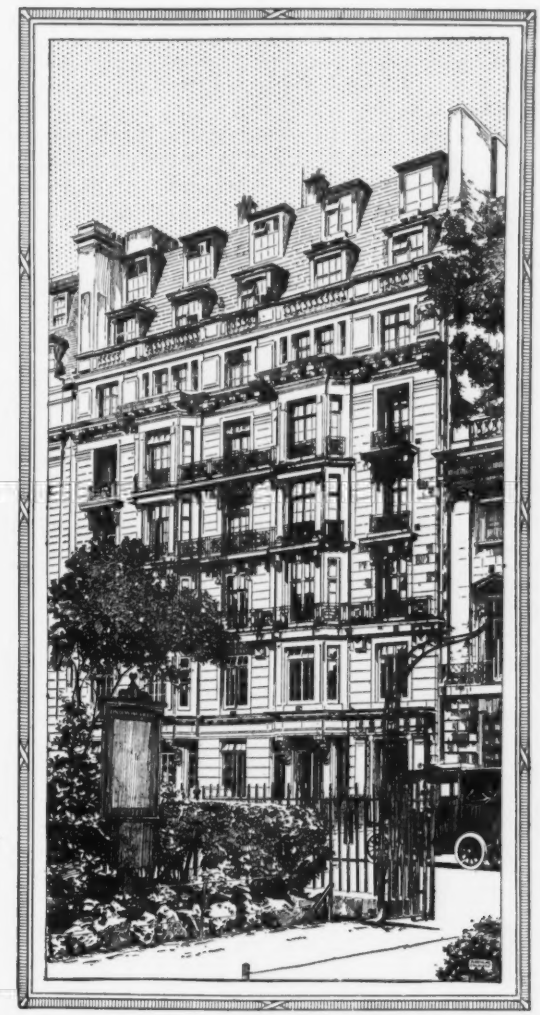
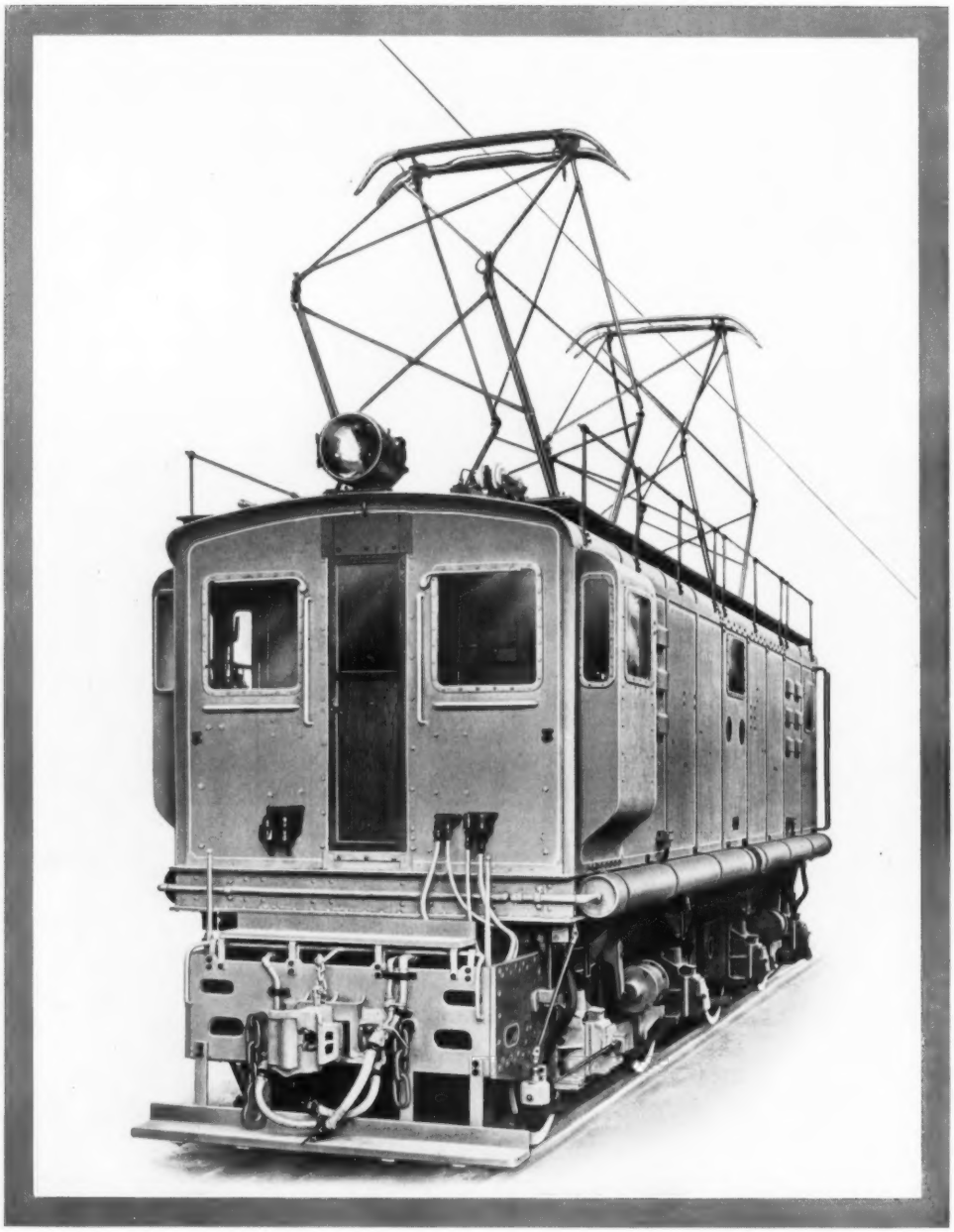
# The ENGLISH ELECTRIC JOURNAL



Queen's House from Lincoln's Inn Fields.

*All rights of republication, including translation of articles, are reserved.*



ONE OF NINE 2400-VOLT D.C. HEAVY FREIGHT LOCOMOTIVES BEFORE DISMANTLING FOR SHIPMENT TO MONTREAL.

# The English Electric Journal

Vol. III. No. 6 DECEMBER, 1926 One Shilling

## CONTENTS.


| | PAGE |
|---|---|
| Electric Traction Works of the Company at Preston | 239 |
| Electrification of the Lines of the Port of Montreal | 251 |
| Electrification of Cape Town Suburban Railways | 259 |
| Electric Traction Equipments in Japan | 264 |
| "Under-car" Control Equipments for 1,500-volt Motor Coaches | 271 |
| New Traction Research Department | 277 |


*All Communications respecting Editorial Contents should be addressed to* The Editor, The English Electric Journal, Queen's House, Kingsway, London, W.C.2.

## EDITORIAL.

The Dick, Kerr Works at Preston have been engaged in the manufacture of traction equipments ever since they were built in the year 1900, and their traction products are in daily operation in all parts of the world. For many years the Works also undertook other lines of manufacture, but since they became part of the "English Electric" organisation it has been possible to distribute these subsidiary manufactures among the other Works of the Company, and thus to enable the Preston Works to concentrate solely on material for traction purposes. This is in accordance with the Company's general policy of specialising in each of its Works on the class of manufacture for which that particular Works is best suited, with a view to obtaining the maximum efficiency in management, design, and production. In particular, this policy of specialisation enables mass production methods most readily to be adopted.

Many changes have been effected at Preston, and much new equipment has been added in order to bring the Shops thoroughly up to date, with the result that at the present time there are no Works more completely equipped for the manufacture of traction material. The Works as a whole are divided into two separate factories, in one of which motors, control apparatus and accessory parts are manufactured, while in the other factory trucks and car bodies are constructed and assembled. In the two factories taken together the whole field of traction work is covered, including locomotives and rolling stock of all classes and sizes, tramcars and equipments, industrial locomotives, railless cars, and, in the Car Building Shops, bodies for motor 'buses.

This issue of the Journal is devoted to a description of the Works, and of some of its manufactures, though, owing to the limitations of space in this publication, it is only possible to make a selection of the latter. However, taken in conjunction with the traction articles that have appeared in past issues, a fairly comprehensive view of the Company's traction work can be obtained. As regards the work now described, it may be noted that the Montreal locomotives, which are dealt with in a special article, are the most powerful four-axle freight locomotives in the world, and that on the first four being put into commission, a repeat order for five further locomotives was received. A further article deals with certain of the locomotives and equipments that have been supplied to the railways in Japan, and here again a large portion of the work is the result of repeat orders.

In a third article the equipments being supplied to the South African Railways are described, and another article is devoted to the under-car type of camshaft equipment. Finally, we give a description of the Traction Research Department, which is an important feature of the Preston Works organisation. The plant at the service of this Department has recently received some notable additions, and the Department has at its disposal a fully-equipped test track laid with several different gauges, which enables running tests to be made under actual service conditions. With this equipment research work of all kinds can be undertaken, and in the rapid development of electric traction at the present time these facilities are of ever-increasing importance.

# The Electric Traction Works of the Company at Preston.

FIG. 1. TEST DEPARTMENT FOR RAILWAY AND TRAMWAY MOTORS.

The Dick, Kerr Works of The English Electric Company Limited, at Preston, are the largest Works in this country devoted to the development and manufacture of electric traction material. Their situation is advantageous, as Preston possesses excellent facilities for handling both raw materials and finished products by sea and rail; the Works are immediately adjoining Preston Docks and are adequately served by railway sidings, with tracks to all parts of the Works. In addition, as shown in the plan reproduced in Plate I, facing page 250, the Works are bisected by Strand Road, a wide thoroughfare that permits the transport of goods by road to be easily effected.

The total area of the whole Works is 32½ acres, of which 14 acres are under roof. Although in effect one united whole, actually the Works are divided into two separate organisations; one, lying mainly on the west of Strand Road, is devoted to the electrical side of the business, while the other, on the east side of Strand Road, is concerned with the production of tramway rolling stock. The former has a total floor area of 416,000 sq. ft., and the latter of 329,000 sq. ft. Each side has its own general and drawing offices.

Dealing with the electrical side of the Works, the Main Machine Shop consists of two bays, parallel to Strand Road, with a floor area of 80,000 sq. ft. Up-to-date machinery is installed for the cleaning up and finishing of traction motor frames and armature shafts. Each bay has three overhead travelling cranes with lifting capacities up to 80,000 lbs. Energy is supplied in this department, and in all others,

FIG. 2. 22 H P. TRACTION MOTOR FOR AUTOMATIC TRUCK.

in the form of electricity and compressed air. A subdivision of the shop is set aside for the manufacture of pantographs.

Parallel to the Main Machine Shop is another bay covering a floor area of 55,000 sq. ft. and similarly provided with three overhead cranes. This bay includes, at the northern end, the Stamping Shop, where the complete manufacture of laminations for core-building is carried out. In the middle is the Small Machine and General Assembly Shop, Fig. 4, and at the southern end the Traction Motor Testing Beds, of which a view is given in Fig. 1. The latter extend across to the foot of the Main Machine Shop and adjoin the Shipping Department so that the motors may be removed and shipped immediately their tests have been completed.

Beyond the Assembly Shop is situated the Winding Department, rebuilt upon modern lines within the last year and covering an area of 24,000 sq. ft. Three overhead cranes are installed, suitable to the weights to be lifted, also spacious steam-heated ovens for drying and baking, with an easily controllable temperature range. The shop is divided into two sections; in one the forming and insulating of armature, field and interpole coils is carried out, in the other the winding of traction motor armatures. A corner of the latter is shown in Fig. 5. North of this department are the Lamination Stores and the Brass Foundry, and also the Press Shop, in which gear cases are shaped and passed to the conveniently situated Trimming Shop, where they are trimmed by means of oxy-acetylene cutting plant. To the immediate south of the Winding Department is the Substation, where the power obtained from the Ribble Power Station is converted and distributed to the whole of the Works.

The Control Gear Department is apart from, and to the south of, the main body of the Electrical Works. It occupies a floor space of over 40,000 sq. ft. and is in course of still further extension.

There still remain to be mentioned three departments whose positions may be clearly seen on the plan; the Lamp Works, run in conjunction with the associated firm, Messrs. Siemens & English Electric Lamp Company,with a floor area of 56,000 sq. ft., the Pattern Shop, covering 36,000 sq. ft., and the Canteen, where lunches and teas may be obtained by workers at reasonable prices.

Recently, in order to cope with the growth of the business, it has been necessary to extend the electrical department to the eastern side of

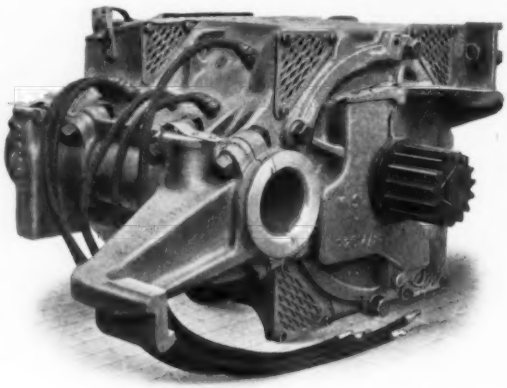


FIG. 3. 72 H.P. TRACTION MOTOR USED ON A POLISH RAILWAY.

FIG. 4. TRACTION MOTOR ASSEMBLY SHOP.

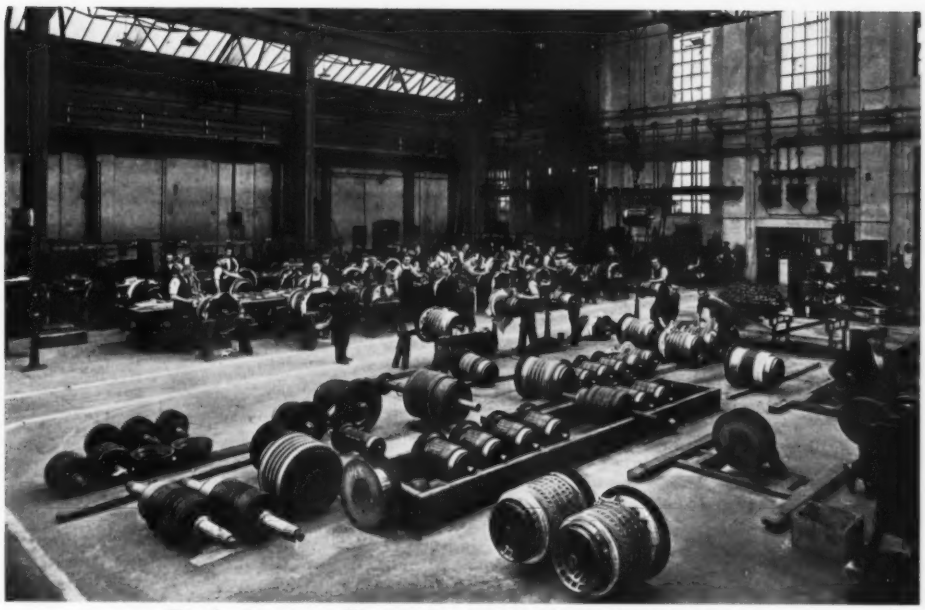


FIG. 5. ARMATURE WINDING SECTION OF WINDING DEPARTMENT.

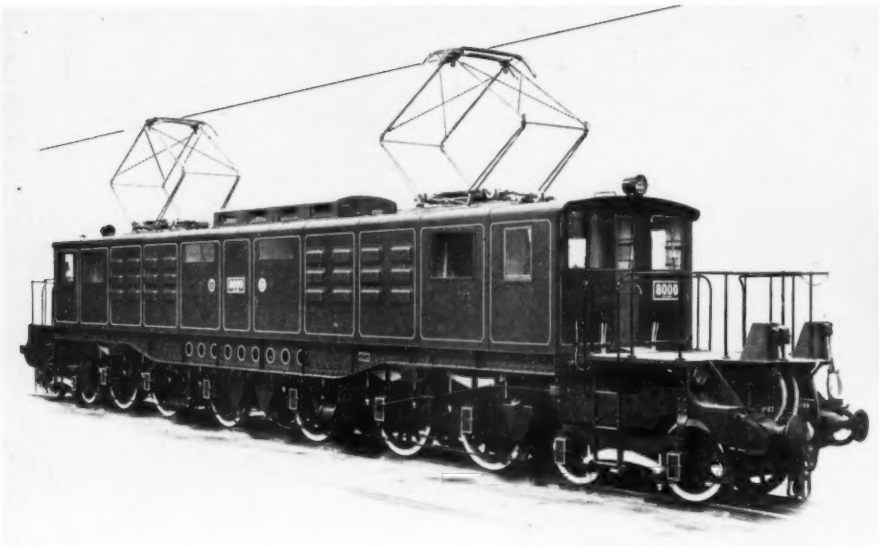



FIG. 6. 100 TON EXPRESS PASSENGER LOCOMOTIVE; IMPERIAL GOVERNMENT RAILWAYS OF JAPAN.

FIG. 7. A LARGE INDUSTRIAL LOCOMOTIVE FOR BATTERY OR TROLLEY WORKING, SUPPLIED TO A CHEMICAL COMPANY.

FIG. 8. CONSIGNMENT OF 63 H.P. TRAMWAY MOTORS FORMING PART OF AN ORDER FOR 550 MACHINES.

Strand Road. There, at the southern end, are the Research and Locomotive Departments. The Locomotive Shop covers an area of 24,000 sq. ft. and is equipped with two travelling overhead cranes of ample capacity. Railway tracks of several gauges run the length of the shop and the Test Track is in immediate proximity so that equipments may be tested under working conditions. The offices of the Railway Traction Department are situated overlooking Strand Road at the northern end, and here estimates for all classes of heavy traction work are prepared and the business and general technical work of contracts carried out.

As already mentioned, the whole Works specialises in traction plant. On the western side all varieties of traction motors are turned out, contrasting examples being the 22 H.P. motors for the G.P.O. automatic underground railway trucks, illustrated in Fig. 2, and the 430 H.P. motors for the Montreal Harbour Board locomotives, of which full details may be obtained from the special article on page 251 of this issue. Illustrations of other typical traction motors for railway and tramway service are shown in Figs. 3, 8 and 11 The Works are well laid out for this specialised mass-production, with No. 4, the centrally situated Assembly Shop, as the focus towards which the various component parts converge; views of the shop are shown in Figs. 1 and 4. The rough frame castings arrive at the northern end of the Main Machine Shop and move gradually down it until, the heavy machining having been completed, they run on bogies into the Small Machine Shop for finishing, and thence to the Assembly Department. There the field and interpole coils and leads and the brush gear are fitted, after which the frames are ready to receive their armatures which are brought in from the adjacent Winding Department. Every armature is carefully balanced before leaving the Winding Department, Thus, once the armatures have been fitted, the complete motors pass, after an orderly progression through the shops, into the Test Department.

The test beds are equipped for all varieties of tests, and although the motors are usually tested in pairs by the Series-Hopkinson method, any other test may be carried out at the buyer's request. The production test department works hand in hand with the Research Department on

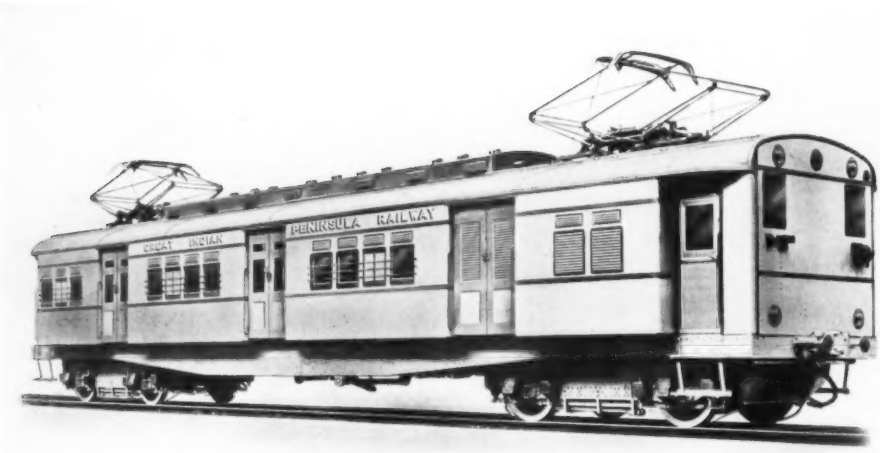



FIG. 9. A MOTOR COACH FOR THE ELECTRIFIED LINES OF THE GREAT INDIAN PENINSULA RAILWAY.

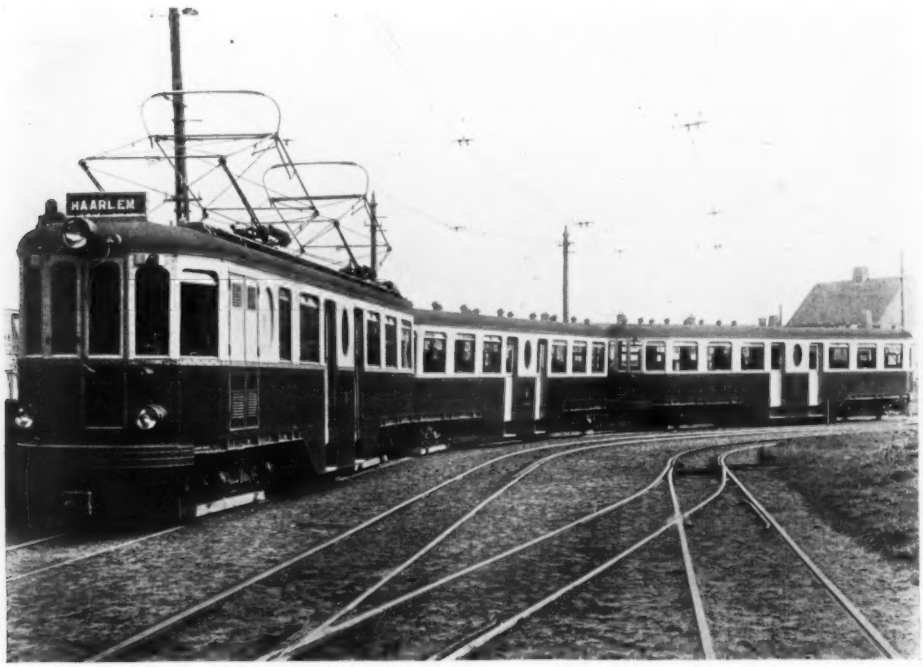



FIG. 10. ELECTRIC TRAIN ON AN INTERURBAN RAILWAY IN HOLLAND.

the other side, assisting the latter, which is equipped on the most scientific lines, in the development and improvement of traction motor design. Their testing satisfactorily completed, the motors are shipped out of the Works, or else to the Locomotive Erection Shop for mounting on their bogies or trucks.

Among the chief contracts for railway motors going through the shops at present are :—

348 motors for South African Railways, 175 H.P., 700 volts.

100 motors for Great Indian Peninsula Ry., 275 H.P., 700 volts.

180 motors for General Post Office, 22 H.P., 440 volts.

80 motors for Warsaw Suburban Railway, 72 H.P., 600 volts.

Tramway motors varying from 35-60 H.P. and for voltages of 500-750 are in progress for Liverpool, Brighton, Birmingham, Campos do Jordao, Dombrowa, Khartoum, Athens, and Tanigumi, also motors for railless omnibuses for Nottingham. Representative illustrations of the various classes of machines are shown in the accompanying pages. The control gear is, as a general rule, manufactured simultaneously with the motors.

The erection of railway motors after completion of their commercial tests takes place on the eastern side of Strand Road, in the Locomotive Department. The wheels and bogies are run in on the tracks laid down the shop, and the motors, bodies, control gear and pantographs assembled in turn. On completion, the locomotives or motor coaches are run out on to the Test Track, of which some details are given

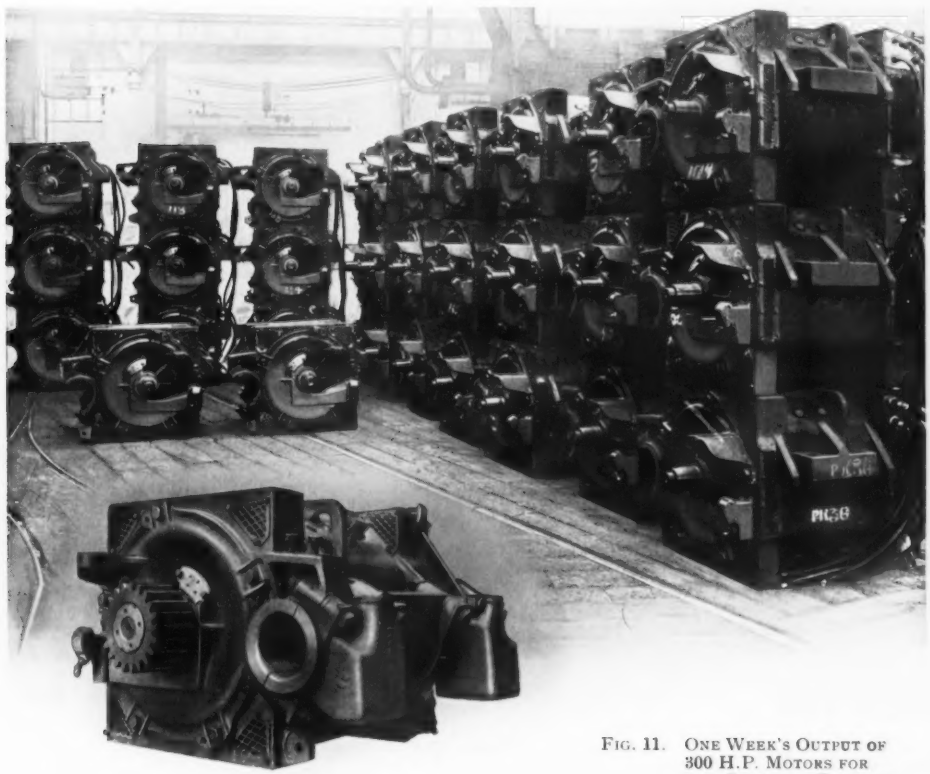


FIG. 11. ONE WEEK'S OUTPUT OF 300 H.P. MOTORS FOR THE SOUTHERN RAILWAY.

FIGS. 12 AND 13. VIEWS IN THE TIMBER STORES.

FIGS. 14 AND 15. CAR BODY BUILDING AND FINISHING SHOPS.

in a separate article describing the Traction Research Department.

The advantages of such a track are incalculable, as it provides a complete test under working conditions, which is very necessary for a Works which, in addition to home contracts, has a large export business.

Turning to the Car Works on the eastern side of Strand Road, the main body of the Works consists of a number of parallel bays which contain : the Smithy ; the Fitting and Machine Shop ; the Body-building Shop ; the Saw Mill ; the Painting Shop ; and the Cabinet Shop. Illustrations of two of these shops appear in Figs. 14 and 15. The total floor area of this building is 127,000 sq. ft. and it includes the steam producing plant, located beside the Smithy. The transfer of jobs from one shop to another is greatly facilitated by electric traversers. The equipment of these departments is thoroughly up-to-date in all respects and the aim has been to concentrate on one class of work in each department. Particular care is paid to the painting and finishing of all coach work. An extension of the Woodworking and Painting Shops is situated in a separate building to the north of the main Works, and still another is located at the southern end of the yard, giving a total additional floor area of 30,000 sq. ft.

The Truck Shop and the Manufactured Iron Stores are in a block of their own at the north-east corner of the Works, and handily situated for the traverser.

Timber, seasoned and seasoning, of which an ample supply is always kept, is contained in outside stores having an area of over 50,000 sq. ft. The two views of the timber sheds, Figs. 12 and 13, give an idea of the vast amount of wood held in stock in order to assure an abundance of thoroughly seasoned timber at all times. Owing to the inflammability of most of the material used in car-body building, a miniature but efficient fire station is maintained,

FIG. 16. TESTING CAMSHAFT CONTROL EQUIPMENT FOR ELECTRIC RAILWAY STOCK.

FIG. 17. SOUTHEND-ON-SEA TRAMCAR ON "BURNLEY" TRUCKS.

FIG. 18. LUXURIOUS UPHOLSTERY IN LYTHAM-ST. ANNE'S CAR.

FIG. 19. AN "ENGLISH ELECTRIC" CAR IN PRINCES STREET, EDINBURGH.

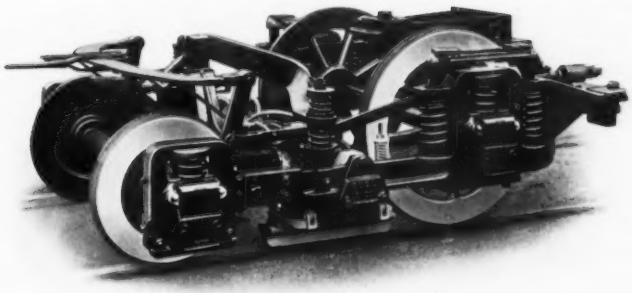


FIG. 20. "BURNLEY" MAXIMUM-TRACTION TRUCK.

and amongst the personnel of the Works is a body of trained firemen. Hydrants are placed in carefully chosen positions throughout the whole of the Works.

On the Car Works side the same orderly principles of routine are applied as are in use on the electrical side. The car bodies move gradually from stage to stage of advancement until they are ready to be placed on their trucks. This is greatly simplified by the traversers at each end of the main building; by means of these, the raw material, after passing through the Woodworking Mill, is directed in turn through the Erecting, Painting and Finishing Shops. The whole work keeps step with that in progress on the electrical side, as most cars leave the Works completely equipped with motors and control gear, thus reducing erection work on site to a minimum. Among the chief contracts in hand are:—

75 car bodies for Leeds,
50 car bodies for Manchester,
50 car bodies for Athens.

There are also in course of manufacture car bodies and trucks for Bury, Nottingham, Norwich, Bolton, Warsaw, Dombrowa, Khartoum, Campos do Jordao and Para. Exterior and interior views of cars and coachwork are shown in the representative illustrations that accompany this article, and these include an example of a motor-bus body built for Madrid. Fig. 20 shows the maximum-traction type of truck known as the "Burnley" truck. Ordinarily over 100 cars are in progress simultaneously, while the capacity of the Works exceeds 500 cars per year.

FIG. 21. MOTOR-BUS BODY FOR MADRID.

FIG. 22. A TYPICAL LOCOMOTIVE FOR GENERAL HAULAGE AND SHUNTING PURPOSES.

An important and growing department of the Traction business of the Company is that concerned with the supply of small haulage units and locomotives for service in industrial undertakings for shunting and general transport purposes. A wide range of these machines has been designed to suit practically every requirement, and views of typical large and medium locomotives are shown in Figs. 7 and 22 respectively, while Fig. 23 shows a unit of much smaller size. With costs of production largely governed, as they are at the present day, by the expenditure on labour, the electric locomotive offers to all manufacturers a means of effecting a considerable economy in running and upkeep charges, and there is no doubt that the near future will see a great extension in its use.

In recent years The English Electric Company has done much towards the advancement and development of electric traction, and they may claim to have contributed largely to the popularity of electric locomotion at home and abroad. To-day, despite general industrial depression, the combined Works give steady employment to over 2,250 men. The keynote of the organisation is specialised mass production, aided by the most modern practice in design, and the most up-to-date workshop equipment.

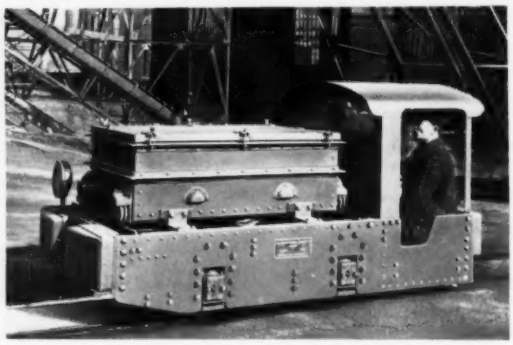
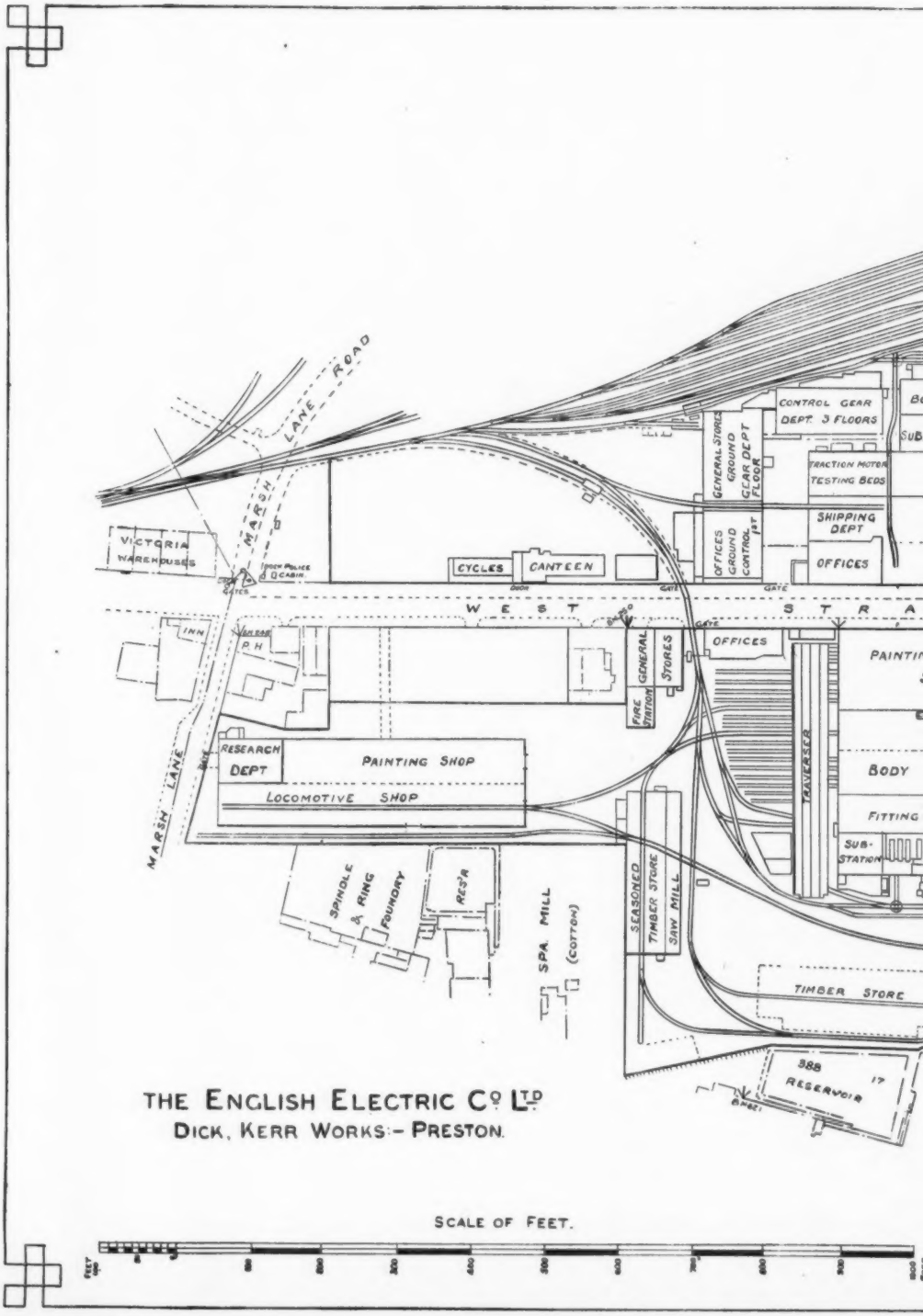


FIG. 23. SMALL BATTERY LOCOMOTIVE AT AN ELECTRICITY WORKS.




THE ENGLISH ELECTRIC Co LTD
DICK, KERR WORKS:- PRESTON.

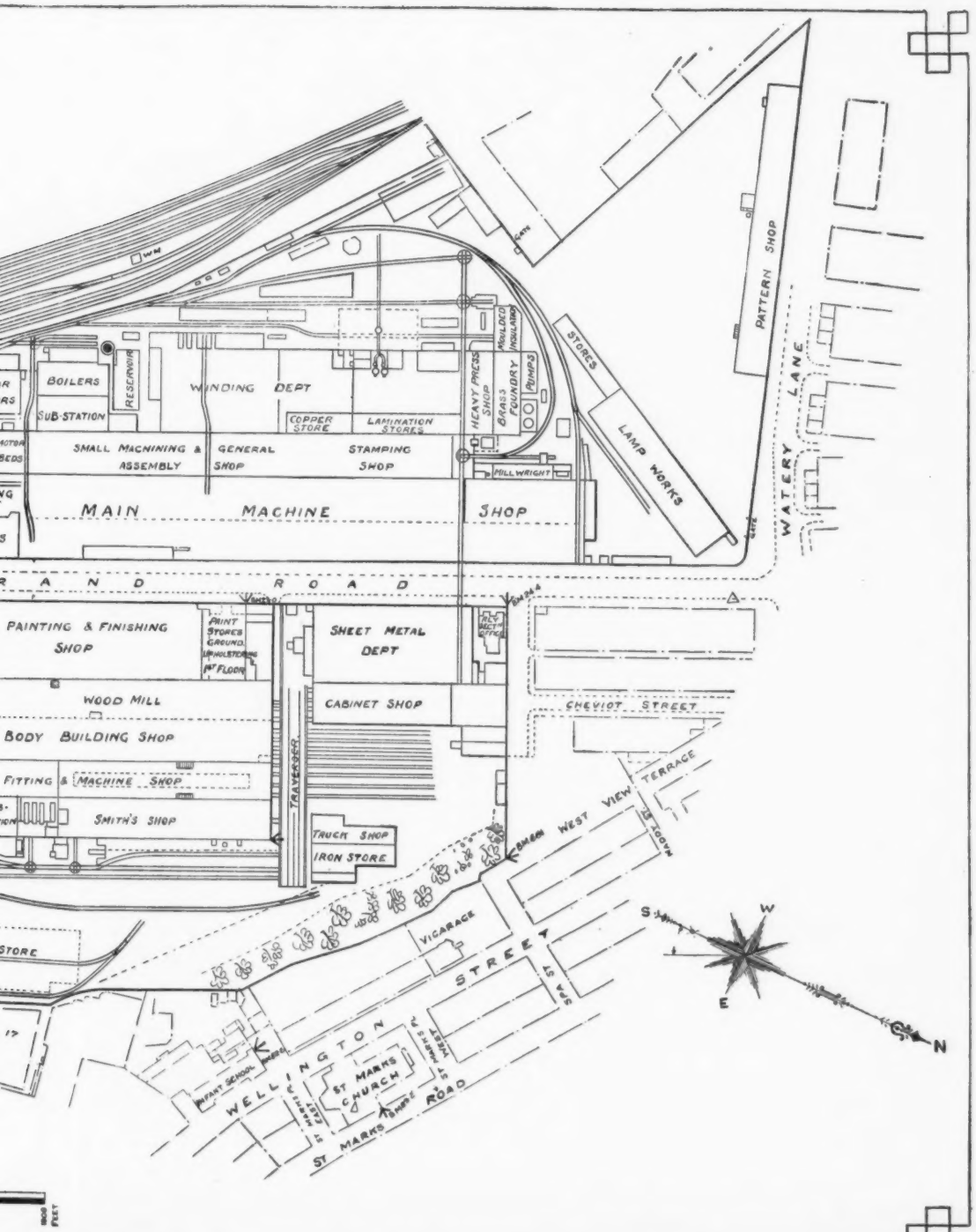



PLATE I.

*The English Electric Journal*]

# Electrification of the Harbour Lines of the Port of Montreal.

FIG. 1. 100-TON, 2,400-VOLT LOCOMOTIVE HAULING A 5,000-TON TRAIN.

One of the most interesting orders executed by The English Electric Company in recent years has been that received from the Harbour Commissioners of Montreal for the supply of electric locomotives and substation plant. In the first place it is a good example of the almost unlimited use that can be made of electric power, and particularly of its application to the complicated tracks of a large harbour. Its second point of interest lies in the design of the locomotives themselves, both on account of the high voltage of operation and because these locomotives are the most powerful four-axle freight locomotives in the world.

This article will describe only the locomotives and the substation motor-generators, but it may be mentioned that in addition to this material, which was manufactured in England, The English Electric Company of Canada have supplied a very large number of transformers and motors for operating the plant in the grain elevators and refrigerators throughout the port. No. 3 elevator, the last to be completed, has been equipped entirely with motors built by that firm.

Previous to the complete electrification of the harbour, the Commissioners rented two electric locomotives from the Canadian National Railways for temporary use, as an experiment in electric traction ; subsequently they commenced operation with the first four of their own locomotives in the Spring of 1925. These machines, which were entirely built and equipped in England by The English Electric Company, are illustrated in Fig. 2, which shows a general view taken in the harbour.

The system of supply was finally settled at 2,400 volts direct current, in order to conform to the existing supply on the Montreal tunnel section of the Canadian National Railways, with which through-running may be arranged at some future date. Electric power is derived from motor-generators converting from a 12,100-volt, 63-cycle, 3-phase, A.C. supply to 2,400 volts D.C.

Simultaneously with the supply of the first

FIG. 2. FOUR OF THE LOCOMOTIVES IN SERVICE IN THE PORT OF MONTREAL.

four electric locomotives, this Company supplied two 1,000-kW. motor-generator sets, which, together with an existing set of the same capacity, are installed in the substation of the port. These motor-generator sets feed the overhead conductors for the tracks, which consist of single 4/0 copper trolley wire with single catenary suspension. Span wire construction has been generally adopted owing to the very large number of tracks to be covered, and the whole of this work has been carried out by the Harbour Commissioners' staff.

## Substation Machinery.

As mentioned above, the supply of power for the locomotives is provided by three 1,000-kW. 2,400-volt D.C. generators, the second and third of which were manufactured at this Company's Stafford Works. Two further machines of similar type, making four in all, have just been completed to a repeat order. Each machine consists of a 2,300-volt, 63-cycle, synchronous motor, coupled to two 1,200-volt, D.C. generators, the latter being connected in series and the whole unit running at a normal speed of 756 R.P.M.

These machines are of standard "English Electric" construction and designed to cope with the heavy overloads normal to a traction system. They are capable of carrying three and a half times full load for a period of five minutes. The generators are fitted with compensating windings to assist commutation during overload. The excitation for the motor and the generators is supplied by overhung exciters, one at each end of each set, and the field windings of the two generators are connected in series. Fig. 3 shows the first three machines in the substation at Montreal.

Special protective features have been embodied in these machines with a view to avoiding the possibility of flash-over due to short circuits on the system. The commutators are made of the same diameter as the armatures, and a

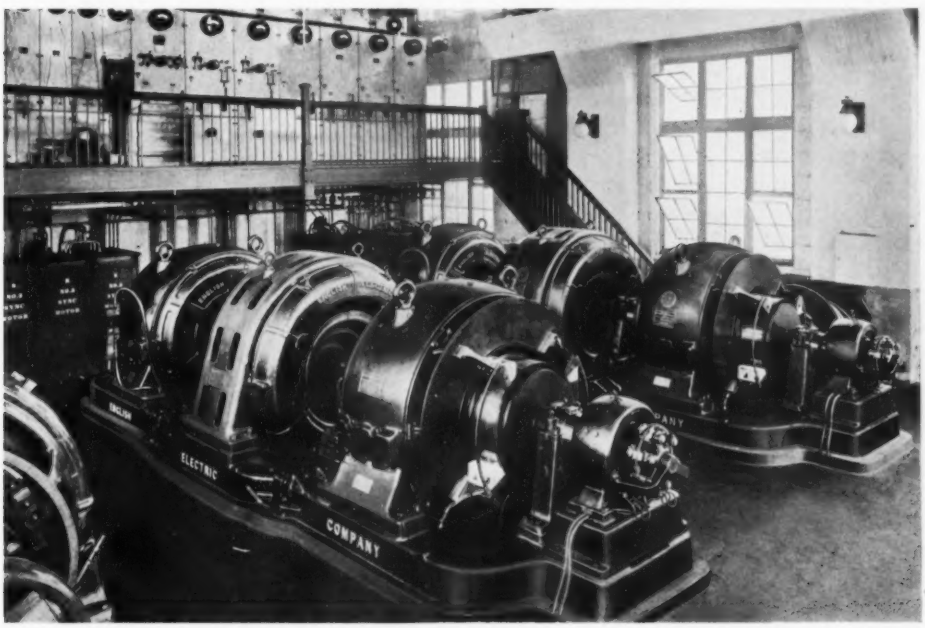



FIG. 3. SUBSTATION CONTAINING THREE 1000-KW. MOTOR-GENERATORS FOR SUPPLYING 2400-VOLT D.C. LINE.

propeller type fan fitted between the commutator and the armature provides a powerful air flow in an axial direction over the commutator surface. In addition, barriers of fireproof material protect the field windings and brush gear, and arc chutes are provided at the leading edge of each line of brushes. The purpose of the latter is to cool and expel the gases generated by the flash; this is effected by drawing in cool air by the injector effect of the arc chutes and by the gases striking on a copper cooling plate.

Accidental short circuits on the system have been without any detrimental effect on the generators.

## Locomotives.

The first order consisted of four locomotives and the second order of five, the machines for both orders being identical with the exception of one or two minor details. General views of one of the locomotives are shown in Fig. 5 and the frontispiece. They are of the articulated, double-bogie, four-axle type, and the superstructures are of the box cab design.

To enable shunting operations to be carried out safely and with the minimum of fatigue for the operator, special arrangements had to be made to provide a driving position from which the operator could have a view in both directions. The locomotives are, therefore, constructed with the usual driving position at one end, but at the other end the driver's cab projects on both sides so as to give a clear view up and down the track; this cab is fitted with duplicate controls, one at either side. This arrangement enables the operator to carry out all shunting operations from one end of the locomotive, the driving position at the other end being used only when it is the leading end on long hauls.

Each locomotive is equipped with four single-reduction twin-geared motors, one driving each axle; one of these machines is shown in Fig. 4. Each motor is capable of giving 430 H.P. at the one-hour rating, and is of the forced-ventilated type, receiving air through a sliding joint from fans mounted on and driven by the motor-generator set in the body of the locomotive. The motors provide a tractive effort at the tread of the wheels up to 70,000 lbs. per locomotive, and as a result, the locomotives have been able to handle, as single units, the largest train that it has been necessary to bring into the docks. The heaviest train so far recorded as being hauled, single-handed, by one of these locomotives, weighed 5,240 tons; this was brought to the docks by two steam locomotives and then taken over by one electric locomotive and hauled to the distribution point near the wharves.

The locomotives are arranged for working in multiple-unit if required. The control equipment is all-electric, embodying the camshaft control principle developed by The English Electric Company. The essential points of this control are its simplicity, the absence of finely regulated valves and complicated interlocks, and

FIG. 4. 430 H.P. TRACTION MOTOR.

FIG. 5. ONE OF THE LOCOMOTIVES ON THE TRACK AT MONTREAL.

the closing and opening of all control contactors in definite sequence by means of an electrically-driven camshaft.

The control apparatus, the main starting resistances and the motor-generator set and compressors, are arranged down each side of the locomotive leaving a straight central passage-way from end to end. The resistances, which are specially rated for shunting service, are housed in four compartments situated at each corner, thus giving an even weight distribution. They are of the grid type built up in frames and supported by mica-insulated steel bars.

The high-tension control equipment is mounted entirely in one large control compartment which is, however, further subdivided to form separate compartments for the lightning arresters, the choke coils, and for the apparatus controlling the auxiliary machinery. The high-tension control compartment is protected by substantial sliding doors which are interlocked with the main switch in such a way that they cannot be opened whilst the switch is closed, and the switch cannot be closed if the doors are open. The opening of the inner door to the auxiliary high-tension compartment is similarly interlocked with the auxiliary high-tension switch. Fig. 7 shows the main high-tension control compartment with the camshaft-driven contactor groups in the foreground.

In accordance with the standard design of " English Electric " camshaft control, all operating current is broken by two line breakers in series, and the current is not broken on the camshaft controller itself. Complete protection is given to the equipment by a main circuit-breaker connected in front of the line breakers and operated by its own overload coil and by two overload relays, one in the circuit of each pair of motors. This main circuit-breaker can, in addition, be tripped by the operator from each driving position in case of emergency by means of a push button.

Opposite to the high-tension control compartment are situated the motor-generator set and compressors. The motor-generator set consists of a 50 H.P., 2,400-volt motor driving a 16 kW., 120-volt generator and also two fans, each of which supplies ventilating air to two of the traction motors.

The generator supplies current for control and lighting, and also for the two compressor motors, each driving a 50 cu. ft. compressor, which are synchronised so as to operate together.

Fig. 6 shows a general interior view of a locomotive. It will be noted that the arrangement adopted for the apparatus gives not only an ample passage-way through the locomotive, but ready access to all pieces of apparatus.

The questions of adequate ventilation and heating call for special consideration in the case of a climate such as that of Montreal. On account of the extreme cold, all windows are of double glass, and the driver's cabs are heavily lagged with heat insulating material and suitably lined. Each cab is warmed by means of a 6-kW., 2,400-volt heater.

Alternative methods of providing a supply of air for the central compartment of the locomotive are used in winter and in summer. In the side walls of the locomotive two large openings are provided and fitted with slat type louvres, and these openings can be completely closed on the inside by means of hinged folding type shutters. The normal procedure is to keep these open in summer and closed in winter.

During the summer, the fans for ventilating the main motors draw their air through these louvred openings. In the winter, the fans draw air through openings in each of the resistance compartments, and air which has previously been passed over the main resistances, is thus drawn through the locomotive. Owing to the very low temperature of the outside atmosphere the air is not unduly heated by this arrangement.

The normal ventilation of the resistance compartments is by means of holes in the floor and suitably cowled openings in the roof, also plain hooded louvres on the outside of the locomotive.

As a precaution against condensation taking place in the traction motors in cold weather, a heating switch and plug is provided by means of which, after the locomotive has finished its work, all the field coils of the main motors can be connected in series and plugged directly on to an outside 220-volt supply.

The two driving compartments of the locomotive are entirely separated from the centra

FIG. 6. INTERIOR OF LOCOMOTIVE, SHOWING MOTOR-GENERATOR AND FAN SET.

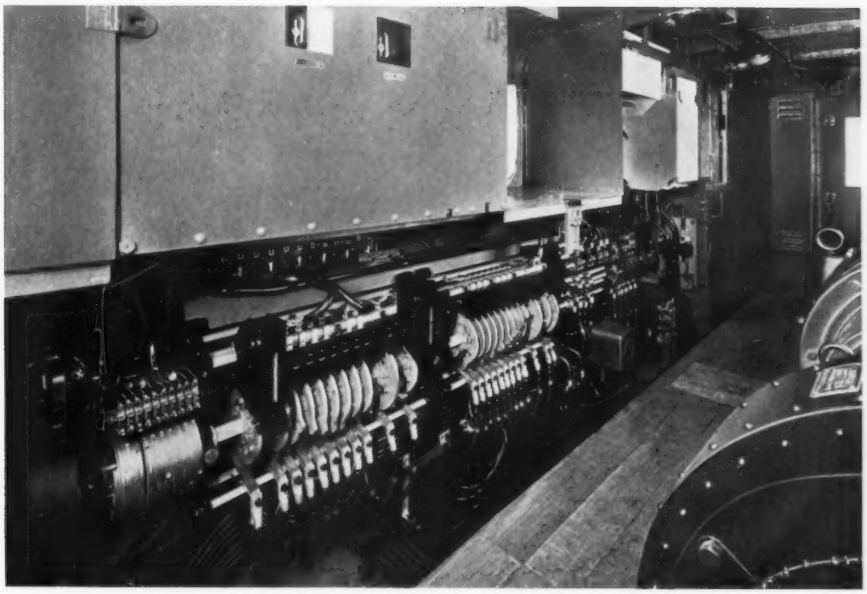


FIG. 7. HIGH-TENSION COMPARTMENT AND CAMSHAFT CONTROLLER.

portion by means of hinged doors. Each of the three master controllers, two in one driver's cab and one in the other, provides eleven series and eight parallel notches, and of course " forward " and " reverse " positions.

To the right of each controller are situated the driver's brake handles and also sanding valves arranged to sand the locomotive in either direction from any driving position. There are also mounted within the driver's reach, the push button for the emergency operation of the circuit-breaker, the main control switch, and whistle and bell valves. The ammeter and pressure gauges are mounted on panels directly in front of the driver.

The driving windows are large and give a perfect field of view. The end windows are provided with two window wipers, operating from diagonal corners, which together sweep the whole surface of the window ; the windows giving a rear view from the larger driving compartment are similarly fitted.

All the cables inside the control compartments are carried on cable racks, and where they cross the floor they lie between the main floor of the locomotive and a false wooden floor, which extends throughout the passage-ways and the driver's compartments.

The motor cables are brought into connection boxes fitting flush with the floor of the locomotive, as shown in the illustrations, the covers being easily removable so that all motor connections can be attended to from the interior. The resistance cables are brought up to a terminal bar at the bottom of the compartment, and connection is made to individual tappings of the resistances by means of bare copper strip.

The first four locomotives went into service early in February, 1925, and were so highly successful that an order for five more was placed towards the end of 1925, and these commenced operation in August of this year.

It is not without interest to direct attention

to the fact that although built and equipped in England, these locomotives have been fitted with all the details necessary to conform to standard Canadian practice. Only those who are acquainted with the operating conditions in the two hemispheres will appreciate to the full how many points of difference there are in the small details, and how important these variations are to the apparatus.

FIG. 8 UNLOADING LOCOMOTIVES AT MONTREAL.

The locomotive trucks and superstructures were built to the order of The English Electric Company by Messrs. Beyer, Peacock & Company, Limited, of Manchester, and the equipments and motors at The English Electric Company's Works at Preston, England, where the complete units were assembled and equipped.

Fig. 8 shows two of the locomotives being unloaded at Montreal by means of the Harbour Commissioners' 70-ton floating crane. In spite of their large size it was possible to ship the locomotives complete, the trucks being removed from under the superstructure and the whole sent in three main packages, consisting of superstructure and two trucks. The main motors were shipped mounted in the trucks. Special arrangements were made so that the locomotives could be towed from the wharf to the point of erection on their own wheels, and owing to the complete state in which the units were shipped, it was found possible to put them into service in ten days after their arrival.

# Electrification of Cape Town Suburban Railways.

One of the principal railway electrification schemes now being carried out in South Africa is that of the Cape Town Suburban Railways.

The sections of line being equipped for electric working are from Cape Town to Simonstown and from Monument to Sea Point, comprising about 16 miles of double and 11 miles of single track. The electrical equipment for the rolling stock is being manufactured at the Preston works of The English Electric Company to the order of the South African Railways and Harbours Administration. The work covered by this contract comprises the complete electrical equipment for :—

83 motor coaches.
37 driving trailer coaches.
95 non-driving trailer coaches.

The motor coaches will be supplied with direct current on the overhead line system at a nominal pressure of 1,500 volts. The mean working pressure will be 1,400 volts.

At the present moment manufacture of the material is well advanced and shipment is in progress. A complete equipment has been erected on the sample coach shown in Fig. 2, which has now been in operation for a considerable time on the Preston Works test track, on which it has been satisfactorily tried out under severe conditions, involving several hundreds of hours continually starting and stopping.

The equipments being supplied are the latest type of " English Electric " all-electric camshaft control, together with the necessary traction motors and auxiliaries, all equipments being arranged for multiple-unit working.

The motor and driving trailer coaches are each equipped with one driving end. Each motor coach is equipped with four D.K. 98A motors, two on each bogie. The output of this motor, which is illustrated in Fig. 1, is 187 horse-power at 225 amperes and 700 volts, and provision is made for field tapping. The motors are connected in pairs, the two motors of a pair being permanently in series, and every machine is insulated throughout for 1,500 volts.

The flexible motor cables are sheathed in flexible metallic tubing and carried into connection boxes fixed to the underframe. Access to the connections is obtained through trap doors let into the floor of the coach.

The drive is taken from the motor to the track wheels through the usual type of spur gearing. All the gear wheels and pinions for this contract have been manufactured at the Rugby works of the Company, and have been machined by special gear cutting and grinding machines which are installed there. The gear wheel consists of a heat treated rim shrunk on to a cast steel centre, and the pinion is a forging which is machined, hardened, and ground after hardening.

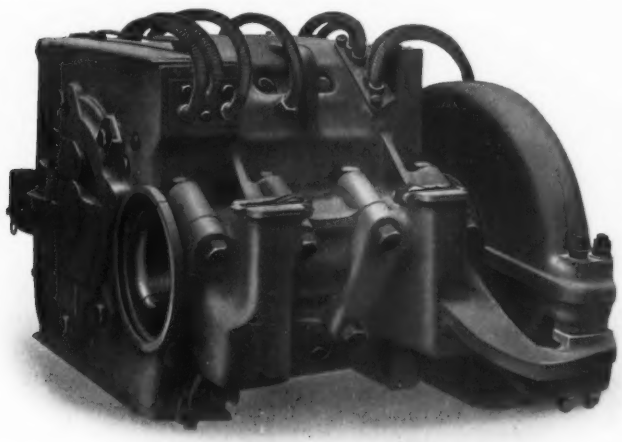


FIG. 1. D.K. 98A MOTOR ; 187 H.P.

FIG. 2. MOTOR COACH WITH "ENGLISH ELECTRIC" EQUIPMENT ON THE TEST TRACK AT PRESTON WORKS.

Current is taken from the overhead line through a choke coil and a fuse to the main isolating switch, a lightning arrester being connected in front of the choke coil.

The control gear is accommodated in each motor coach, in main and auxiliary high-tension compartments which are situated immediately behind the driver's compartment. The main high-tension compartment contains the main circuit breaker, line breakers, camshaft contactors, reverser and minor pieces of apparatus. Fig. 3 is a view looking through the door of the main high-tension compartment and shows the more important items of the apparatus.

The auxiliary high-tension compartment contains the main and auxiliary isolating switches, the motor-generator and exhauster motor circuit breaker and the exhauster motor high speed contactor. Fig. 4 shows the apparatus (with the exception of the isolating switches) in the auxiliary high-tension compartment.

The principle of the control and the general design of the apparatus are well known and have been described in full on previous occasions. The doors of the main and auxiliary high-tension compartments are interlocked with their respective isolating switches. This ensures the complete isolating of all power circuits in the main high-tension compartment when its door is open, but at the same time permits the apparatus to be run round for inspection. The auxiliary isolating switch is interlocked not only with the compartment door but with a control cock which lowers the pantograph.

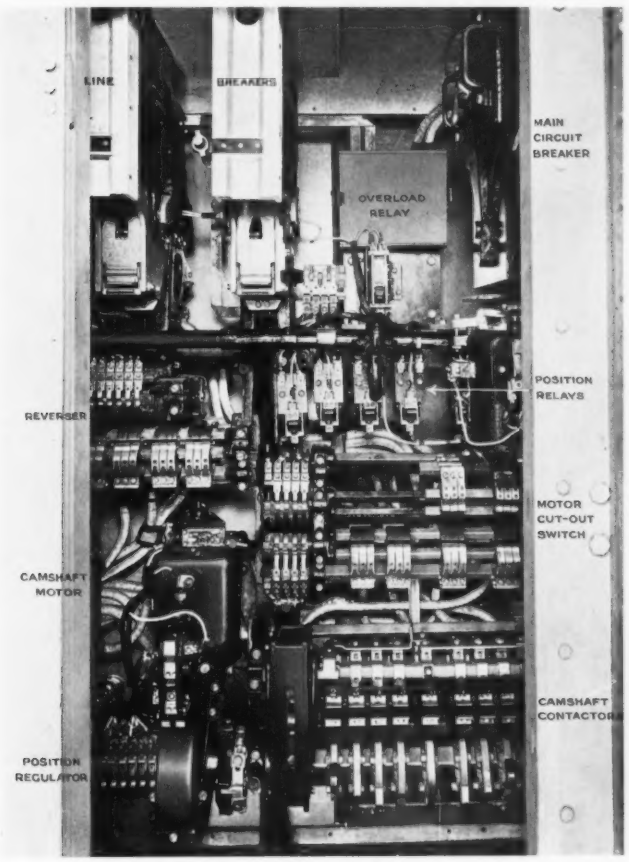



FIG. 3. MAIN HIGH-TENSION COMPARTMENT.

Each motor coach is provided with two vacuum controlled pantographs either of which can be used, as determined by the position of a selector cock in the driver's compartment. Each motor coach takes its power direct from the overhead line by one of its own pantographs only, there being no power couplers between coaches. The raising and lowering of the pantographs throughout the train is controlled by electrically-operated valves in the motor coaches, these valves being operated by a master switch in the driver's compartment.

Fig. 6 shows the arrangement

of apparatus on the roof. Current for the control and lighting is supplied at 110 volts from a 5·5 kW. motor-generator. Each motor coach is fitted with a three-way selector switch so that its low-tension supply may be taken either from its own motor-generator or from the one on the next motor coach in front of or behind it on the train. Similarly, each trailer coach is fitted with a two-way switch, so that its low-tension supply may be taken from the motor coach in front of or behind it.

Each motor coach equipment includes an exhauster set consisting of a 1,400 volt motor coupled directly to a Reavell rotary exhauster. This exhauster runs continuously and maintains a vacuum of 20 inches of mercury in the train pipe, except during a brake application, when it is cut off by an electrically operated valve. When the brakes are released, the exhauster is automatically speeded up by the operation of a contactor controlling the field of the driving motor, so that the train pipe vacuum is rapidly restored. Both the exhauster and the motor-generator are accommodated underneath the coach, their bedplates being fixed to slings attached to the coach underframes.

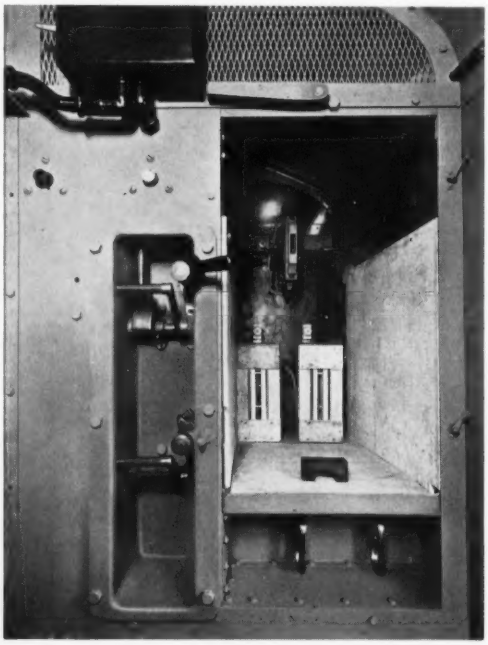


FIG. 4. AUXILIARY HIGH-TENSION COMPARTMENT.

The main starting resistances are also mounted under the coach in one of the bays of the underframe.

Each driving position, whether in a motor coach or a driving trailer coach, is equipped with a master controller, vacuum brake operating valve, pantograph control switch, overload resetting switch, selector switch for motor-generator circuits, ammeter and vacuum gauge. In addition, the driving cab of a motor coach is provided with a control cut-out switch, which isolates the complete control equipment of that coach, and a hand pump for raising the pantographs when no vacuum is available.

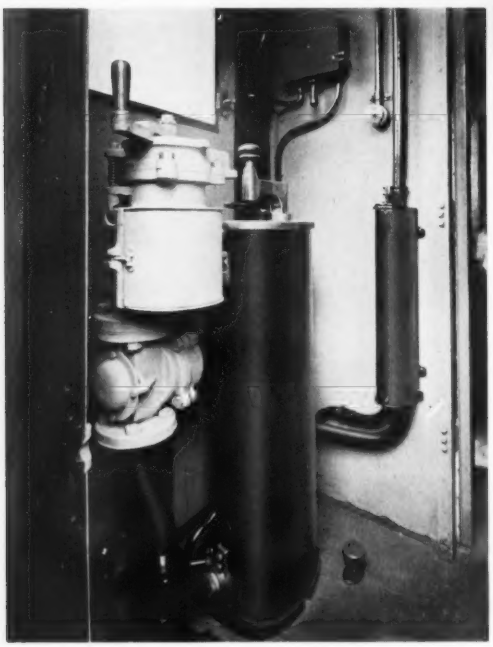


FIG. 5. DRIVING POSITION.

Fig. 5 is a view of the driving position in a motor coach.

The control system employed gives a total of twelve notches on the master controller, three of these—full series, full parallel, and field tap—being running notches ; the acceleration of the train takes place automatically up to the particular connection corresponding to the notch on which the handle of the master controller is placed.

All power cabling is suitable for 1,500 volts, and is run in heavy gauge conduit from the high-tension compartment to the resistances and motor connection boxes. The control cabling consists of 19-way multicore cable run in conduit and connected at each end of the coach into two connection boxes built into the coach ends.

These two connection boxes are connected respectively to a coupler socket and, through a flexible multicore cable, to a coupler plug. The couplers and plugs are of standard multiple unit pattern.

There is also a two-way low-tension bus line running the length of each coach and connected at each end, through the same connection boxes as the 19-way control cable, to two-way coupler sockets and plugs. These low-tension bus lines are connected through the selector switches on the motor coaches to the motor-generator sets and supply the current for the lighting and control circuits throughout the train.

We hope to give in a later issue further particulars of these equipments when they have been put into service in South Africa.

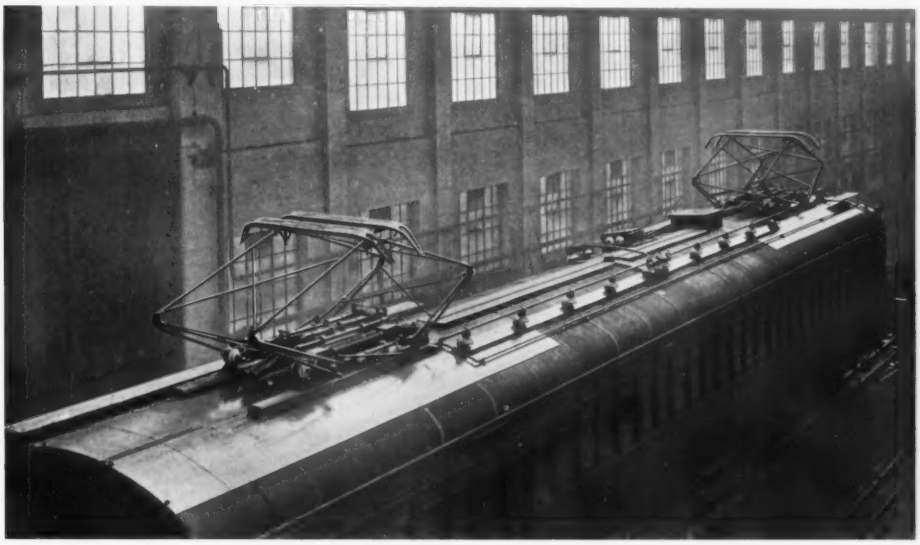


Fig 6. Pantograph Equipment on Roof of Motor Coach.

# "English Electric" Traction Equipments in Japan.

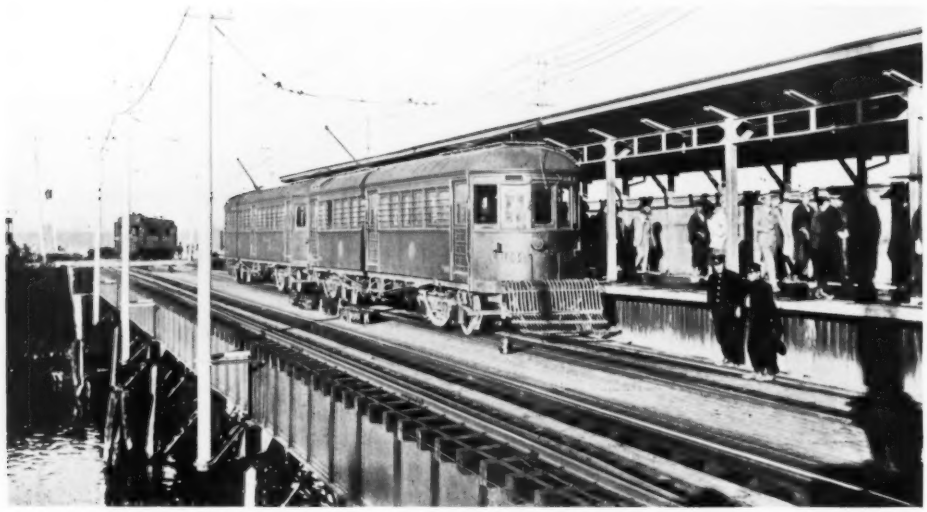


FIG. 1. MOTOR-COACH TRAIN AT A TERMINAL STATION OF THE KEIHAN RAILWAY.

As is well known, considerable progress has been made in Japan in electrifying main line railways, interurban railways and city lines. Previous to the war, Messrs. Dick, Kerr & Co. had a well-established reputation in that country for tramway equipments, and in the development of electric traction that has taken place since, The English Electric Company has had a considerable share. In the limited space now available it is impossible to give more than a brief reference to the individual systems, but the bare summary is a sufficiently imposing testimony to the tremendous progress that Japan is making; at the same time, it is satisfactory evidence of the efficient service rendered by this Company's camshaft controller and motor equipments, under conditions which differ, in many respects, from those ruling in this country.

The principal order executed in recent years has been the thirty-six main line locomotives for the Japanese Government Railways, which have been described in previous issues of this Journal. It is proposed, in the present article, to refer to the numerous equipments supplied to privately owned lines.

In every case the control equipment supplied has been standard "English Electric" camshaft control, the principles of which remain the same whether applied to locomotives, motor-coaches or light multiple-unit tramway equipments. In another part of this number the 1,500-volt under-car type of camshaft equipment is described, and this description applies generally to all the 1,500-volt motor coach equipments which have been supplied to Japan. The 600-volt equipments are very similar, except that the trolley voltage is used directly for the control without the employment of a motor-generator.

## Motor-Coaches.

*Keihan Denki Tetsudo K.K. and Shin Keihan Tetsudo K.K.*

The first mentioned Company has been operating an electric service between Osaka and

K.K. = Kabushiki Kaisha = Limited Company; Tetsudo = Railway; Denki Tetsudo = Electric Railway.

Kyoto since 1909, when the Power Station and Substation plant and the Rolling Stock Equipments were supplied by Dick, Kerr & Company. Subsequently numerous repeat orders were received for standard coach equipments, each consisting of four 50 H.P. motors with direct manually operated control. In recent years their new rolling stock has been equipped on the multiple-unit system and, so far, 20 sets of "English Electric" Camshaft Control Equipment have been supplied, each consisting of four 72 H.P. motors and control gear.

From the allied Company, Shin Keihan Tetsudo K.K., orders have been received for 10 equipments of the latest type, each comprising four 60 H.P. motors and control equipments for operating on a 600-volt line. This system, which connects Juso and Senri, is of interest since the Company contemplates converting it to 1,500-volts, and the coach equipments have been arranged to facilitate easy conversion to meet future requirements. Fig. 1 illustrates a motor coach train on the Keihan Railway, and Fig. 5 a train on the Shin Keihan system.

*Ome Tetsudo K.K.*

The first camshaft equipments were those supplied to the Ome Tetsudo K.K., whose first order comprised four control equipments and motors; repeat orders have been received for a further four equipments. The line voltage of this system is 1,200 D.C., but is presently to be raised to 1,500 volts. The normal composition of the train consists of one motor coach and a trailer, but sometimes two trailers are used, and on special occasions a train is made up of two complete units. Fig. 2 illustrates a three-car train on this system.

The motors, four of which are mounted on each motor car, are connected in pairs in permanent series, and each is rated at 60 H.P.

*Nagoya Denki Tetsudo K.K.*

This Railway has an electrified line running

FIG. 2. 3-CAR MOTOR-COACH TRAIN ON THE OME RAILWAY; 1200/1500 VOLTS D.C.

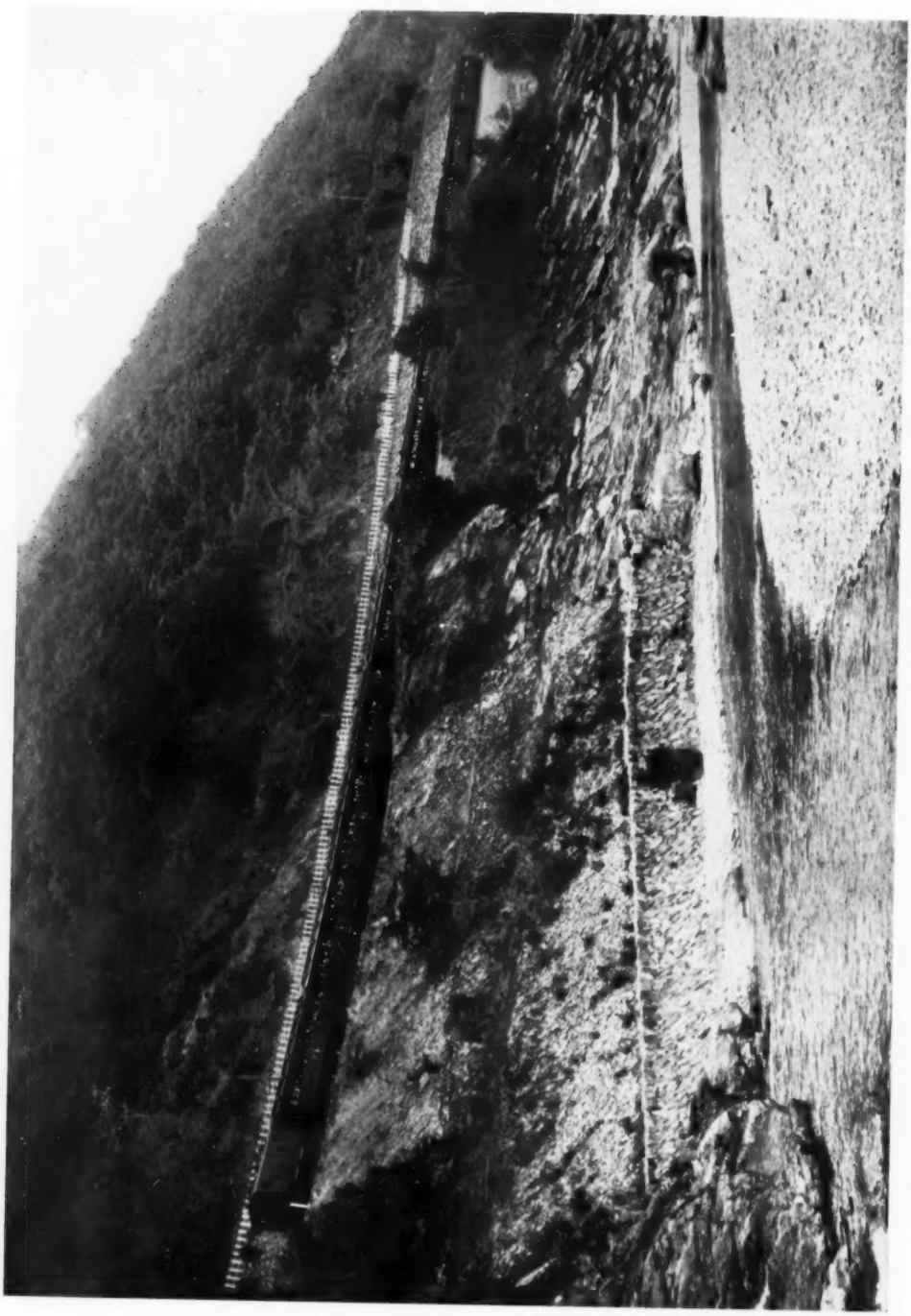


FIG. 3. 12-COACH TRAIN BEING HAULED UP A 1% GRADE ON THE CHICHIBU RAILWAY BY "ENGLISH ELECTRIC" LOCOMOTIVE.

FIG. 4. 2-CAR MOTOR-COACH TRAIN ON THE NAGOYA RAILWAY.

between Nagoya, Iwakura and Ajiyama, operating on 600 volts D.C. The normal train make-up is a two-car unit, consisting of two motor cars.

The first equipments supplied consisted of ten sets of control equipment, each operating two 84 H.P. motors. The cars are, of course, equipped for multiple-unit operation, and Fig. 4 illustrates one of the trains in service.

This system operates a heavy suburban traffic, and the average mileage run per car is 50,000 miles per annum. After the first equipments had been in operation for about eighteen months, a repeat order was received for six sets of control equipment, each operating four 84 H.P. motors, the motors being built by the associated company, Messrs. Toyo Denki Seizo K.K. This year the associated company received a further order for ten complete equipments, which they have built to the same designs as those supplied on the second order.

*Keisei Denki Kido K.K.*

This Railway Company operates a system from Oshaige to Tsadanuma, with a further extension to Narita. The operating pressure is 600 volts on the first portion of the line, and 1,500 volts on the second portion. The service on these lines is very severe, each car averaging approximately 65,000 miles per annum.

For operating on the 600-volt section, The English Electric Company supplied six four-motor equipments, each motor being of 75 H.P., followed by a repeat order for eleven similar equipments. The associated company in Japan subsequently received an order for twenty-five equipments to operate on both 600 and 1,500 volts, and are manufacturing these to " English Electric " designs.

*Kongozan Denki Tetsudo K.K.*

Two orders have been executed for this Company, the first for three and the second for four camshaft control equipments, each operating four 60 H.P. motors on a 1,500-volt line.

*Kagamigahara Tetsudo K.K.*

On different orders a total of eight control equipments have been supplied, each operating four 60 H.P. motors on a 600-volt supply.

*Toyokawa Tetsudo K.K.*

This Company's lines operate on 1,500 volts, and six control equipments have been supplied, each controlling four 80 H.P. motors built by the associated company in Japan, and a further three equipments, each controlling four 95 H.P. motors, built at this Company's Preston Works.

In addition to those already mentioned, the following railways have camshaft equipments in use or on order :—

| | |
|---|---|
| *Tobu Tetsudo K.K.* | Ten equipments, each of four 130 H.P. motors on 1,500 volts. |
| *Tanigumi Tetsudo K.K.* | Ten equipments, each with two 60 H.P. motors on 600 volts. |
| *Mino Denki Kido K.K.* | Ten equipments, each of two 50 H.P. motors on 600 volts. |

## Locomotives.

Many of the privately owned railways in Japan which are not purely suburban services carry a considerable amount of freight, and locomotives are, of course, employed for this work. "English Electric" locomotives are now working on the lines of three of these systems.

*Toyokawa Tetsudo K.K.*

At the same time that the first six sets of motor-coach equipment were ordered by this Company, two electric locomotives were constructed. These are of the central cab type, the superstructure being mounted on two articulated bogie trucks, with all buffing and hauling stresses carried through the trucks. Each locomotive is equipped with four 80 H.P. motors connected in pairs in permanent series, and operated by standard locomotive camshaft control.

The locomotives had to be as light as possible, and were, therefore, designed with a total weight of 25 tons distributed equally on the four axles.

The whole of the camshaft control equipment is contained in one of the sloping ends of the locomotive, while the other end houses the

FIG. 5. 2-CAR MOTOR-COACH TRAIN ON THE SHIN KEIHAN RAILWAY.

motor-generator for supplying low-tension current, the air brake compressor and the auxiliary switches. The central cab is equipped with two driving positions, with all the necessary auxiliary control switches, driver's brake handles, etc.; Westinghouse A.M.M. air brakes are fitted.

These locomotives have been in operation for nearly two years, and recently a further order was obtained for the camshaft control equipment of a larger locomotive of the box type, the mechanical parts of which are being built in Japan. The general arrangement of this locomotive will be very similar to that of the locomotives for the Chichibu Tetsudo K.K., described in the following paragraphs.

*Chichibu Tetsudo K.K.*

Two 42-ton locomotives have been built for the above railway. As will be seen from Fig. 7, the locomotive superstructures are of the box type and mounted on two articulated, plate frame, two-axle bogie trucks. The draft gear is of the M.C.B. type standardised for the Japanese railways, and is fixed on to the outer ends of each bogie. The superstructure rides on the bogie centres through spherical type lubricated seatings.

Each locomotive is equipped with four DK.98B motors, each of 200 H.P., connected in pairs in series for operation on a 1,200-volt supply.

The superstructure is divided into a driving compartment at each end, and a central compartment. The latter is arranged with a straight passage-way from end to end; on one side of this is the enclosed high-tension control compartment housing the camshaft control gear, and on the other, an enclosed compartment containing the main resistances. A 2-kW. motor-generator set for supplying low-voltage control, and two compressors, are also located in the central compartment. Westinghouse 14 E.L. type air brakes are fitted.

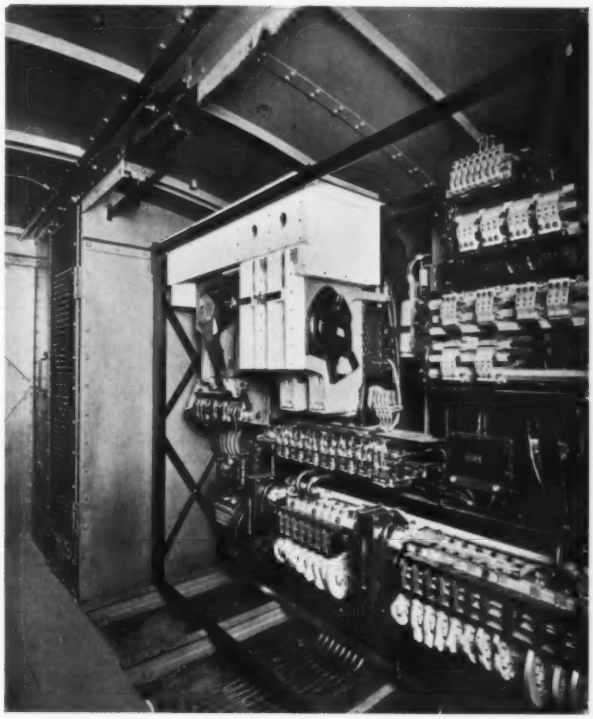


FIG. 6. MAIN CONTROL GEAR ON A LOCOMOTIVE OF THE CHICHIBU RAILWAY.

The current collector gear consists of two air operated pantographs, one of which is normally used in service, the second being for emergency purposes.

The locomotives are arranged for working in multiple-unit. Fig. 3 illustrates a train hauled by one of these machines.

*Ome Tetsudo K.K.*

The Ome Tetsudo K.K., which has been mentioned as being the first Japanese railway to use camshaft control, has also in operation a 36-ton locomotive, which generally is very similar to those of the Chichibu Tetsudo K.K.

This unit is arranged to operate on 1,200 and

FIG. 7. ONE OF THE 1,200-VOLT LOCOMOTIVES SUPPLIED TO THE CHICHIBU RAILWAY.

1,500-volt lines, and is equipped with four D.K. 91 motors, each of 136 H.P., connected in pairs in series. It has now been in operation for about six months with very successful results. As in the case of the locomotives for the Toyokawa Tetsudo and Chichibu Tetsudo K.K., the locomotive was completely equipped in England and shipped in three main portions, namely, the superstructure and the two trucks. This enabled the locomotives to go into operation with the minimum amount of erection work in Japan, and the Ome Locomotive in particular was put into full operation as soon as the superstructure had been mounted on the trucks and connected up.

The results obtained were so satisfactory that a further locomotive of similar type has just been ordered, and is now in course of construction. This locomotive, however, while being capable of working in multiple-unit with the first locomotive, will be arranged for rheostatic braking, as the Ome line practically consists of one continuous grade from end to end, and is, therefore, eminently suitable for electric braking.

*Shin Keihan Tetsudo K.K.*

Three camshaft control equipments are under construction for locally built locomotives on the above railway. The layout of these locomotives will be generally similar to those of the Ome and Chichibu Tetsudo K.K.

The principal feature to be noted about the construction of all the above locomotives is that the camshaft control equipment is mounted on detachable framework in two portions, one frame taking all the main control gear and the smaller frame taking the auxiliary control gear. These frames can be lifted in and out of the locomotives bodily through detachable portions of the roof.

Fig. 6 illustrates main control gear for the Ome and Chichibu Locomotives, which is typical of all.

This type of locomotive is proving very popular in Japan, and its undoubted simplicity and reliability should lead to a considerable extension of its use.

# "Under-Car" Type Equipments for Motor-Coaches on 1,500-volt D.C. Systems.

FIG. 1. STEEL CASE CONTAINING MAIN CONTROL APPARATUS.

From time to time we have published in this Journal accounts of various electric railway systems on which the control is of our standard camshaft type. The purpose of the present article is to describe a standard equipment arranged for under-car mounting and suitable for operation on pressures up to 1,500 volts D.C.

This equipment is designed to meet a requirement common to many parts of the world, but at the moment without general application in Great Britain. Railway electrification in this country has so far been confined mainly to dense traffic areas. For this kind of service, heavy trains are necessary with motors and control equipment approaching the maximum size suitable for motor-coach operation, and the practice is frequently adopted of placing the control apparatus in a compartment of the coach, since the large size of the rolling stock allows this to be done without serious sacrifice of passenger-carrying space. In most parts of the world, however, the problem of inter-communication between town and town is dealt with by medium sized trains, which must provide a fast and frequent service. Electric traction has so many obvious advantages for this form of traffic, that not only is there already a very wide application, but there is a rapidly expanding market for equipments varying from 300 to 600 H.P., and operating on voltages up to 1,500 volts D.C. As a rule the unit of train make-up consists of one motor-coach and one driving trailer, and these units are arranged for operation in multiple unit when required. Obviously, in stock of this nature, it is not desirable to curtail any of the available seating accommodation by building up a control compartment inside the coach, hence the development of what is known as the " under-car " type of equipment.

The " English Electric " control equipment lends itself very readily to this form of construction, as it is inherently compact and robust. Its compactness permits the equipment, which, in detail, is identical with the cab type equipment, to be mounted in the smallest possible size of case. Its general simplicity and the absence of any portion that needs fine adjustment is particularly valuable, since no matter how accessible an under-car type of equipment may be arranged, it cannot, in the nature of things, receive the same attention as an equipment mounted in a compartment inside the coach. In the design of the housing for the apparatus, however, special care has been given to making every part of it easily accessible from the rail level; that is to say, the covers of the equipment are easily removable and every part of the apparatus can be cleaned and

adjusted with the car standing on an ordinary track.

Figs. 1 to 4 demonstrate the method of housing and mounting the apparatus under the coach; they show an equipment suitable for operating four motors on a line voltage of 1,500, the motors being connected together permanently in pairs in series.

The only portions of the apparatus not mounted under the car are the master controllers and the control switches necessary for the motorman's use. These are situated in the driving cab and the circuits they operate are entirely low-tension, the 1,500-volt supply being confined altogether to the under-car portion of the equipment.

The control equipment is operated on 100 or 120 volts, the current being supplied by a small motor-generator mounted underneath the coach. This voltage, which has been adopted as standard for "English Electric" equipments, was selected after considerable experiment and study of actual working conditions as being the most reliable, and, at the same time, a safe voltage for the purpose.

*Main Power Circuit.*

Fig. 2 shows the main control case which contains :—

(1) A pair of cam-operated line breakers.
(2) An overload relay.
(3) The camshaft controller which includes the driving motor, position regulator and the mechanically-operated resistance contactors.
(4) The camshaft motor relay which controls the supply to the camshaft motor.
(5) The small position relays.

Fig. 3 shows the auxiliary control case containing :—

(1) An electrically-operated reverser.
(2) Hand-operated motor cut-out switch.
(3) A main isolating switch and an auxiliary isolating switch, controlling the motor-generator.

These cases are built up of stout steel sheet, mounted on a framework of steel angles which

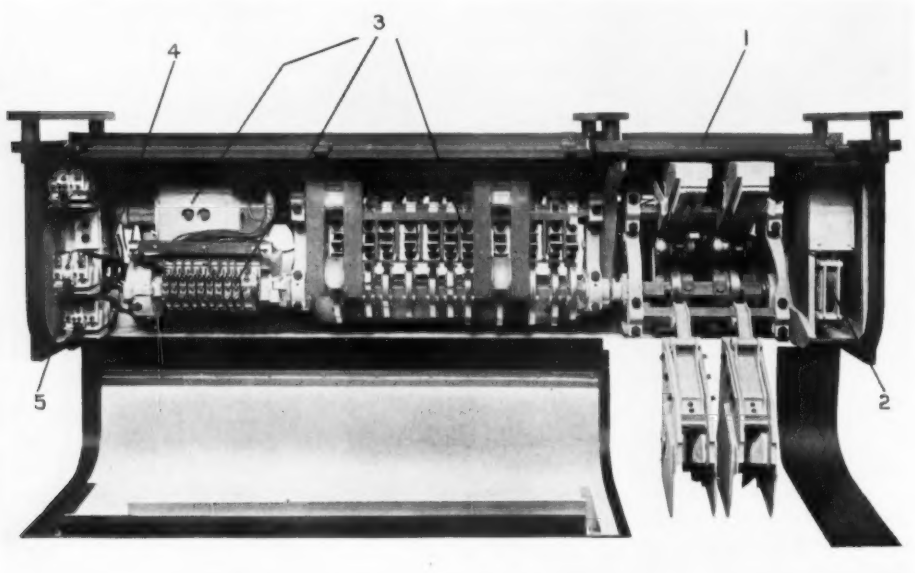



FIG. 2. ARRANGEMENT OF APPARATUS IN MAIN CONTROL CASE.

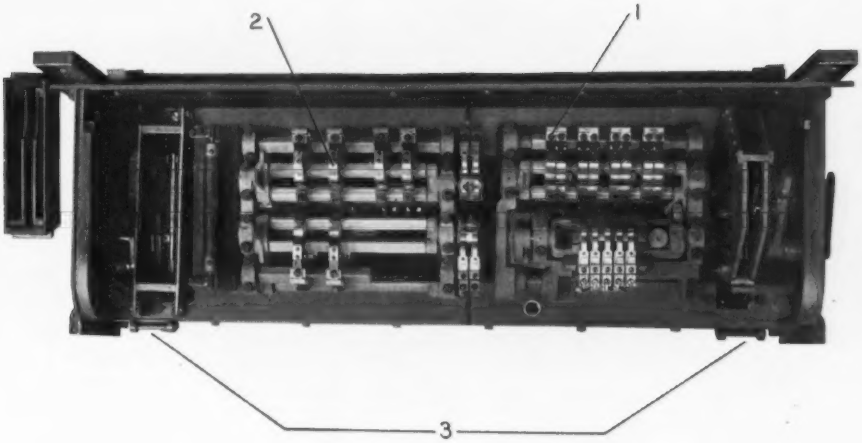



FIG. 3. ARRANGEMENT OF APPARATUS IN AUXILIARY CONTROL CASE.

are arranged to carry also the various items of control gear.

The camshaft controller consists of ten steel cams, giving five series and four parallel notches. These cams are mounted on a mica-insulated steel shaft, rotated by an electric motor through worm gearing. The cams have an angular displacement from one another, and each in turn closes a contactor. Fig. 5 illustrates the arrangement.

Directly coupled to the camshaft motor is a drum type switch called the position regulator, the purpose of which is to ensure that the position of the camshaft always conforms to the corresponding notch on the master controller.

The closing of the camshaft contactors regulates the amount of starting resistance in the main circuit and also determines the grouping of the main motors in series or series-parallel. It will be noted that the progression of the camshaft is entirely mechanical, so that no interlocking is required to prevent the contactors closing in the wrong sequence. The progression of the camshaft is thus definitely determined and there is no possibility of incorrect operation. This being so, it is possible to dispense with blow-outs on the resistance contactors with the exception of the two transition contactors, which are called upon to break small currents during transition from series to parallel.

The line breakers are of the cam-operated type, and each is fitted with a strong magnetic blow-out. They are arranged in such a way during normal operation that, when power is on the motors, before the camshaft can run back to the off position the line breakers must first open and so break the circuit. In the event of overloads the line breakers act as circuit breakers through the operation of the overload relay. The breakers are closed by means of cams on the camshaft and operating links which form a toggle ; this toggle is held straight by holding coils and, unless these are energised, the cams cannot close the breakers.

Upon the supply current to the line breaker holding coils being interrupted, through the return of the master controller to the off position, or the operation of the overload relay, the toggle collapses and the line breakers immediately open under the influence of heavy springs. In the event of failure of the current supply, the line breakers open, due to the release of the operating links, but the camshaft does not return to the " off " position until the current

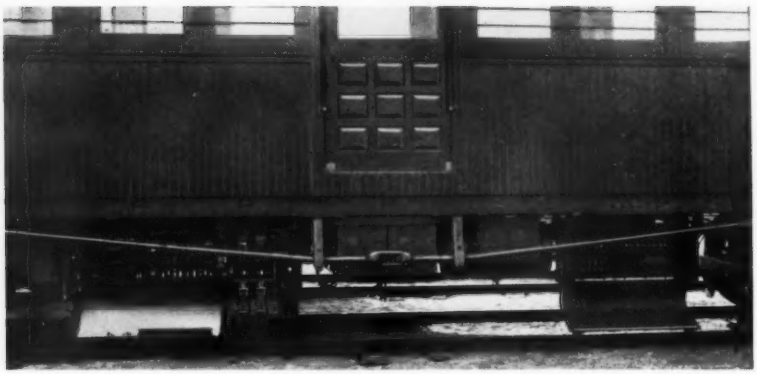


FIG. 4. CONTROL CASES IN POSITION ON A MOTOR COACH.

is restored. The line breakers, however, are not set for closing, even if the master controller be in the " on " position, until the camshaft arrives at the " off " position.

The line breakers are shown at (1) in Fig. 2.

It will be appreciated that as the line breakers are held closed mechanically, their contact pressure is constant and does not vary with the line voltage. As an additional safeguard, in the case of short circuits, a main fuse is provided.

The electrically-operated reverser which is carried in the auxiliary case, but shown separately in Fig. 6, is operated by two solenoids, one for each direction of travel. The armatures of these solenoids actuate the auxiliary contact rocker, which in turn, transmits the motion to the main rocker, through a lever engaging in a tooth and slot. The contacts on the auxiliary contact rocker provide definite electrical interlocks which prevent any further operation of the rest of the control apparatus, unless the reverser is properly thrown into the required position.

The motor cut-out switch, of which an example is shown in Fig. 7, is of the standard drum type, the copper contacts being carried on mica-insulated bars, and is so arranged that it is possible to cut out either pair of motors in case of breakdown.

*The Control Circuit.* The apparatus just described is operated from a low-voltage supply taken from a motor-generator set. The motor of this set is driven from the line and is controlled by means of an auxiliary isolating switch, and protected by a high-tension fuse. The switch is operated by the reverser key on the master controller. A small permanent resistance is provided in series with the motor armature, and the motor-generator set is designed for switching direct on to the line; by this means complicated starting relays are avoided with resultant simplification of the control.

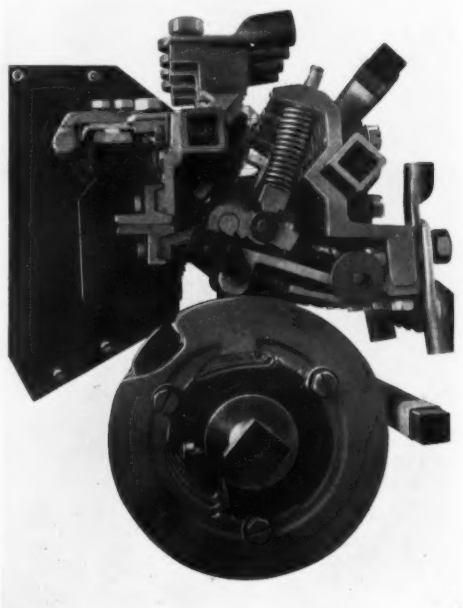


FIG. 5. CAM CONTROLLER CAMS AND CONTACTORS.

The motor-generator set illustrated in Fig. 8 consists of a high-tension motor driving a 120-volt generator of 2 kW. capacity. The armatures of the motor and generator are mounted on the same shaft, together with a ventilating fan, and the frames of the two machines are bolted rigidly together. The generator is compound wound, the shunt winding being self-excited, whilst the motor, which is a two commutator machine, has a small series winding, and a shunt winding excited from the low-tension side. The set supplies the necessary current both for the control of the camshaft equipment, and the lighting of the car.

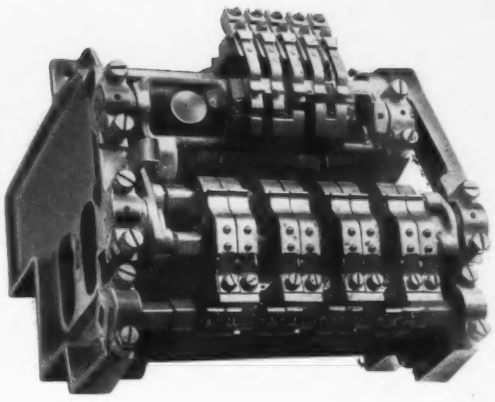


FIG. 6. ELECTRICALLY-OPERATED REVERSER.

In a train made up of two or more motor coaches, the motor-generator set on the leading car supplies both the lighting for its own car and the control current for the whole of the control equipments in the train. A 2-way bus and selector switch is provided, so that in case of necessity, the control current can be obtained in the leading car from a motor-generator set further down the train. Low-tension current is taken into the driving cab through a control and setting switch to the master controller. The master controller is of "English Electric" standard type, arranged for either manual or automatic operation, and is fitted with emergency release. The controller shown in Fig. 9 has five series and four parallel notches, of which 5 and 9 are running notches and the intermediate notches resistance notches. The emergency release is such that in the event of the driver releasing his hold of the master controller handle knob when the

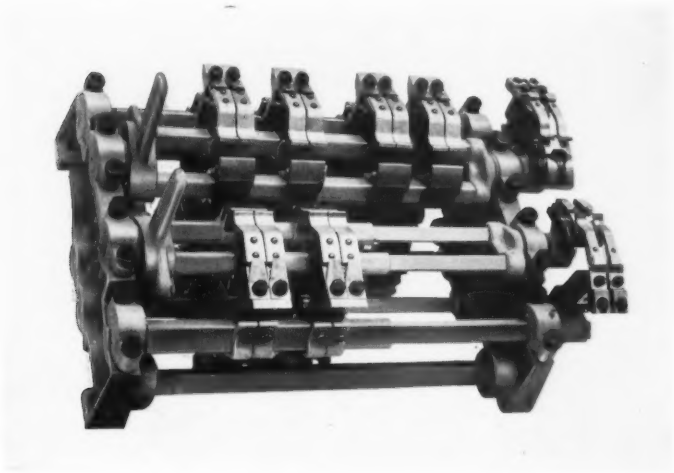


FIG. 7. MOTOR CUT-OUT SWITCH.

controller is in any position except in the "off" position, with the reverser key also in the "off" position, loose segments in the master controller break the control circuit to the line breakers, power is immediately cut off, and at the same time an air valve is operated which puts the brake pipe to atmosphere so that the air brakes are applied.

The reverser handle on the controller has three positions—ahead manual, ahead automatic, reverse manual.

Normally, the control of the camshaft is automatic, so that the camshaft notches up automatically under the control of a current limit relay. In some cases where, owing to overloading or severe gradients, the current limit relay does not permit the camshaft to notch forward, by placing the reversing key handle to the manual position, the position of the camshaft will correspond directly with the position of the master controller handle. It is possible, therefore, to control the speed of notching up independently of the current limit relay, if desired.

FIG. 8. 2 KW. MOTOR-GENERATOR SET.

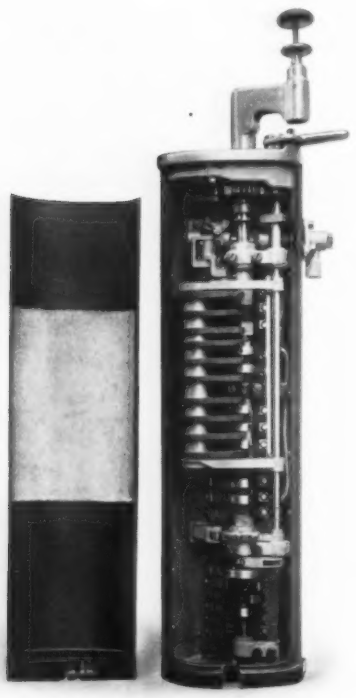


FIG. 9. MASTER CONTROLLER.

The main resistances are built up of unbreakable jointless grids, mica washers separating the grids from each other and also from the sheet steel end frames. The grids are held together between the end frames by means of tie bars insulated with mica tubes. Copper strip connections are made between the various resistance points and are carried to a robust mica-covered terminal bar provided with substantial copper terminals for receiving the connecting cables. Primary insulation is by means of micanite washers and tubes; secondary insulation is by means of porcelain insulators carried on steel tubes which are attached to the sheet steel end plates.

A non-inflammable construction has been adopted throughout. All operating spindles and finger supports consist of steel with mica insulation, and special attention has been paid to the interchangeability of parts, with a view to keeping down the number of spares required. Whilst all the wearing parts are of ample size, they are designed to facilitate renewal when it is required.

Equipments of this type have now been operating in service during the past five years, and some illustrations and details of their application are given in the preceding article.

# New Traction Research Department.

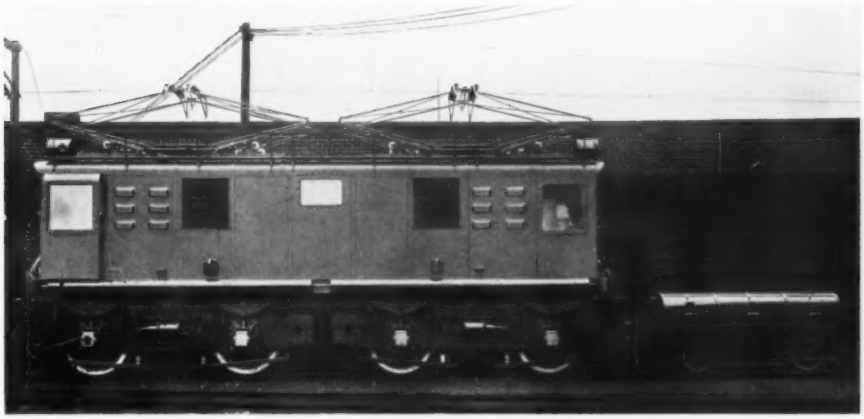


FIG. 1. A HEAVY FREIGHT LOCOMOTIVE AND AN AUTOMATIC TRUCK ON THE TEST TRACK.

An important addition to the Company's resources is the new Traction Research Department, which has recently been inaugurated at its Preston Works. In the past a great deal of scientific investigation has been carried out on the commercial test beds and in the general laboratories of the Company's Works, but the rapid development of electric traction at the present time has pointed to the desirability of organising a separate department for studying the problems peculiar to this application of electric power. The equipment of the new Department comprises a laboratory fitted with special machinery and apparatus for traction tests, and, no less important, an outdoor test track on which tests under actual running conditions may be made.

Although the design of electric traction equipment has hitherto kept pace with the continual advance which has been characteristic of electrical machinery in general, the present world-wide expansion in the use of electric traction necessitates an intensive study of the design of the motors and equipment in order that they may fulfil, in an adequate manner, the increasingly onerous conditions of modern railway service. One of the problems that has continuously to be faced is the accommodation in a limited space of motor units of larger and larger outputs.

The designer of industrial motors is seldom hampered by considerations so rigid as those imposed by gauge, nor has he to contend with the severe fluctuating electrical and mechanical stresses and the exposure to weather which are the commonplaces of railway operation.

There is undoubtedly a wide field for research and development directed towards analysis of the nature and distribution of losses and the higher utilisation of materials, as well as to the elimination of operating difficulties which are brought to light only by actual service on the track.

The general arrangement of the laboratory is shown in the plan reproduced in Fig. 2. The equipment has been planned with a view to obtaining great flexibility and accessibility, so that it can be utilised for a wide variety of testing. Those who are familiar with the usual commercial methods of determining losses in electric motors—based on broad assumptions of average values—will realise that the advantage of direct and accurate measurement of losses cannot be over-estimated from the point of view of

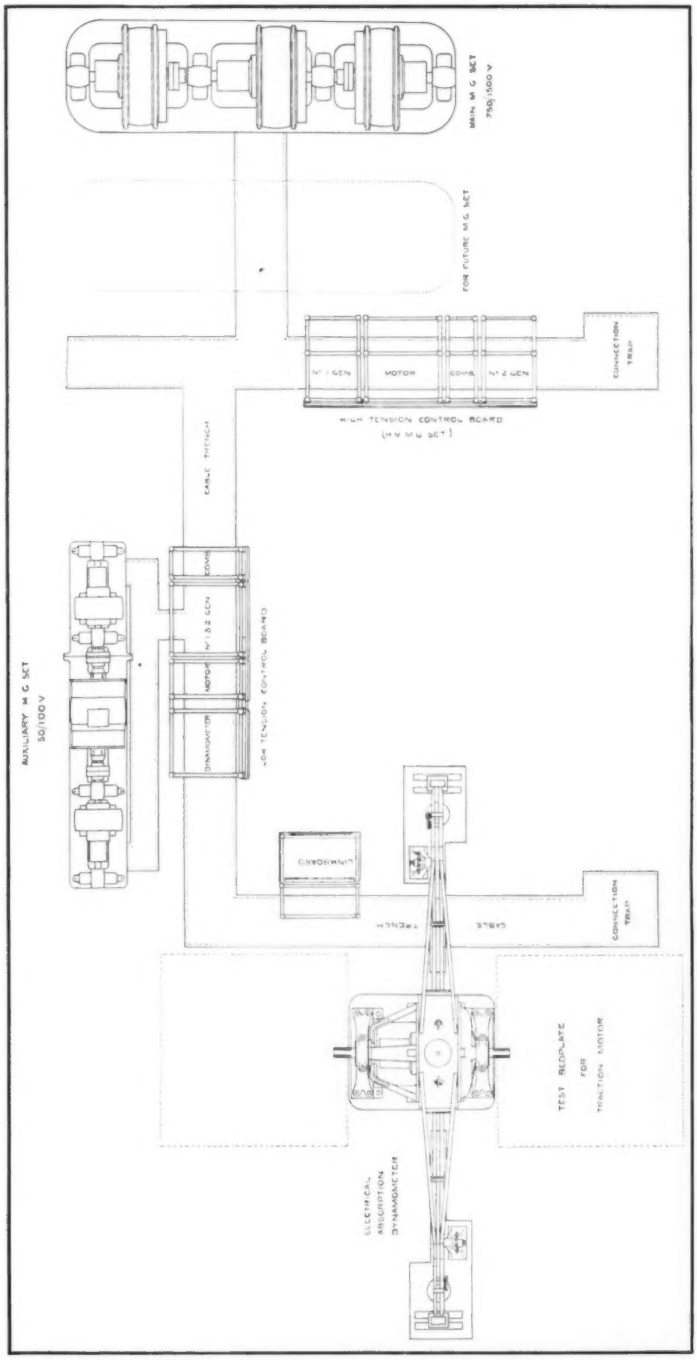



FIG. 2. ARRANGEMENT OF DYNAMOMETER AND AUXILIARY APPARATUS IN THE LABORATORY OF THE TRACTION RESEARCH DEPARTMENT AT PRESTON WORKS.

obtaining reliable design data. In this case the problem has been solved with very satisfactory results by the installation of an electrical absorption dynamometer, specially designed for the work in view. This dynamometer has been manufactured at the Stafford Works of the Company.

Most of our readers are no doubt well acquainted with the general principle of this type of dynamometer or torque balance, in which the magnet frame of a direct current machine is swung on trunnions and provided with steelyard arms, by means of which the torque between the armature and magnet system can be measured. The machine in question, which can be seen in Figs. 3 and 4, has been designed with a number of refinements that render it particularly suitable for carrying out tests on traction motors expeditiously and with a high degree of accuracy. At the same time the arrangement adopted is a flexible one, and either the input or the output of the machine under test can be measured.

Fig. 3 shows a traction motor mounted in position for testing, and it will be noted that a chain coupling, which was supplied by the Coventry Chain Company, forms the connecting link between the two machines. This arrangement has proved very satisfactory in operation.

When the dynamometer is used for measuring the power developed by a motor, its electrical output is fed back into the supply mains, so that the net amount of power consumed is only that necessary to supply the aggregate losses of the system.

The dynamometer is very sensitive, and is designed to measure the torques developed by the large range of traction motors manufactured by the Company, up to a value of 10,000 lb.-feet.

The equipment is extremely simple to operate since full provision is made for adjusting any one of the variables without interfering with the others. Thus the load on the machine under test can be varied by adjustment of the excitation of the dynamometer field, and, as a motor generator set is installed for supplying the traction motor, the terminal voltage can be varied independently of the load. A smaller

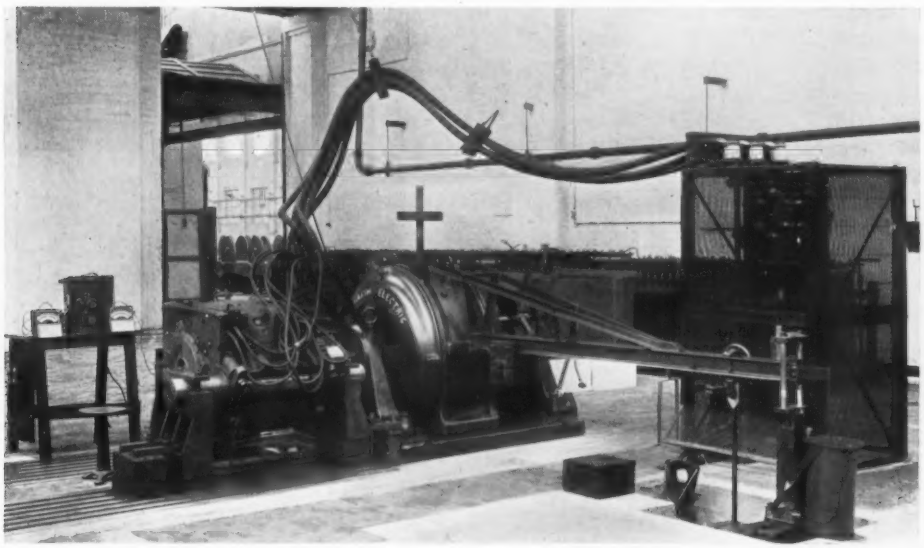


FIG. 3. TRACTION MOTOR ON ONE OF THE TEST BEDS OF THE ELECTRICAL ABSORPTION DYNAMOMETER.

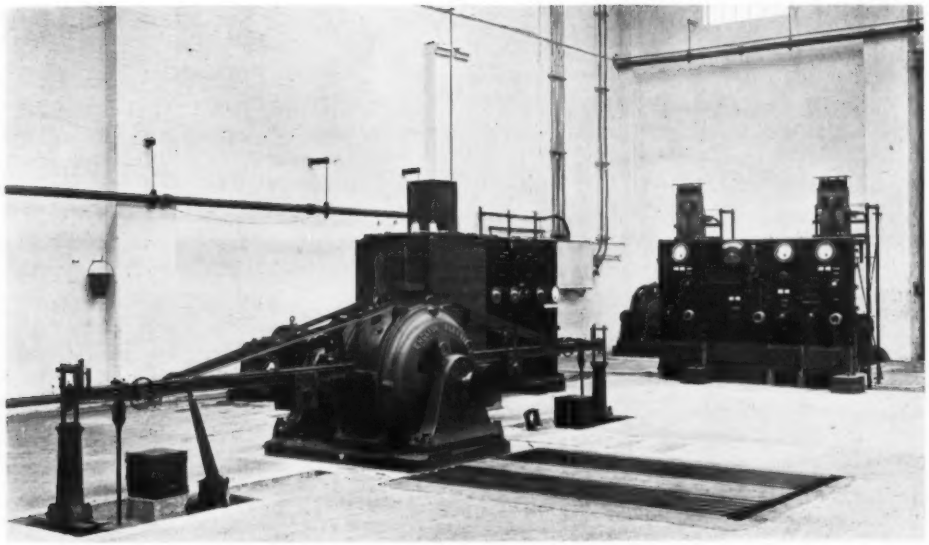


FIG. 4. GENERAL VIEW OF LABORATORY.

motor-generator set has also been installed, and from this any desired separate excitation may be given to the traction motor, so that here again a full range of variation is possible without affecting any other adjustments.

By using the dynamometer as a motor to drive the traction motor under test, the various losses in the latter can be easily evaluated, for the balance arms then measure the output torque of the dynamometer, and this, multiplied by the speed and an appropriate constant, is the mechanical power required to drive the motor, and therefore a measure of the losses under the particular conditions which have been arranged.

The installation is particularly valuable for investigating the one-hour rating of machines. Under ordinary conditions of commercial testing there is an appreciable time interval between starting the motor and getting it on to its rated load, but the dynamometer eliminates this and enables the motor to be put on load almost instantaneously.

In carrying out tests of this description the dynamometer can be run as a motor so as to drive the traction motor at its proper rated speed, and the desired voltage can then be applied to the traction motor from the motor generator set, so that within a very short interval it will have the desired load and commence to drive the dynamometer as a generator pumping power back into the mains.

At the maximum point of its range the dynamometer has an accuracy of the order of one-tenth of one per cent., while at a quarter of this point, readings are correct to within one-quarter of one per cent. Accuracy is not confined to the measurement of torque, as the ammeters and voltmeters installed are of sub-standard grade and are checked for precision at proper intervals, the Department being well equipped with instruments of guaranteed accuracy in order to carry out these and other calibrations. The accuracy called for under sub-standard grade is within one-quarter of one per cent.

The general lay-out of the laboratory has been planned not only with a view to further

extensions, but also with particular attention to economy of time and to the tidiness of connections, etc., which is so great a help to efficiency in carrying out work of this description.

The majority of the cables are housed in concrete trenches with wooden covers, and a special switchboard has been installed to facilitate rearrangement of the connections, thus obviating the necessity of moving the cables. This switchboard, which is illustrated in Fig. 5, has a simple arrangement of studs and bridging

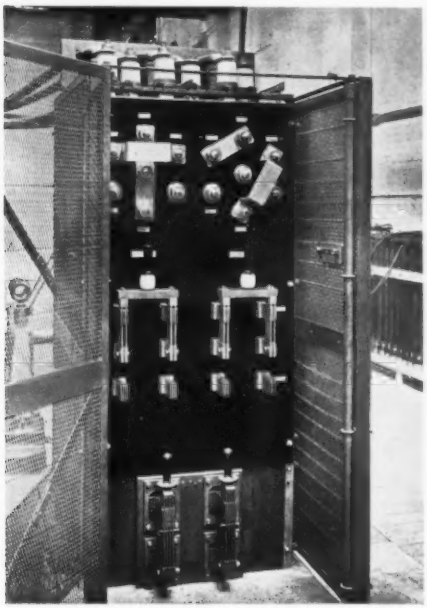


FIG. 5. SWITCHBOARD FOR TEST CONNECTIONS.

links, whereby any desired system of connections can be arranged without disturbing the permanent leads.

While the main purpose of this Department is the investigation of traction motor characteristics, the increasing number of subsidiary experiments that have been undertaken fully justifies the provision of a liberal number of points from which power may be taken for such purposes. In the general view of the laboratory, Fig. 4, it will be seen that each generator panel is equipped with terminals at the base so that current may be taken at any convenient pressure within the working range for purposes other than driving a motor.

Reference to the general plan of the equipment, Fig. 2, will show that the main control panels are grouped on three sides of a rectangle, thus making supervision possible from a central position. This arrangement is not only convenient and economical, but is also conducive to accurate and effective work.

It may here be mentioned that the success which has attended the installation of the dynamometer described above has led the Company to construct a similar machine for use in the Commercial Test Department.

The test track of the new Research Department has a length of 1,350 ft. and is laid with tracks having gauges of 5 ft. 6 in., 4 ft. 8½ in., and 3 ft. 6 in. In addition to a straight portion it includes curves with radii of 9 and 12 chains, and from the locomotive shop to the track is a short stretch with two curves of 5 chains radius, which is equivalent to the minimum met with in railway practice. There is also a vertical curve. In addition to the rails mentioned above, 550 ft. of the track are laid with 2 ft. gauge complete with a live centre rail giving voltages up to 440, and portions of the conductor rail can be made dead as required for testing automatically controlled locomotives.

Overhead power is supplied to the whole of the track on the single catenary suspension principle, and any pressure can be applied to the trolley wire up to 4,000 volts. The height of the overhead wire above ground level is adjustable to suit the varied conditions met with on different railways.

The largest units so far tested have been the Montreal locomotives, of which a full description is given elsewhere in this issue. Fig. 1 shows one of these locomotives on the test track by the side of a 3-ton unit. The large locomotive has an axle load of 24 tons and a total weight of 96 tons, and is designed for running

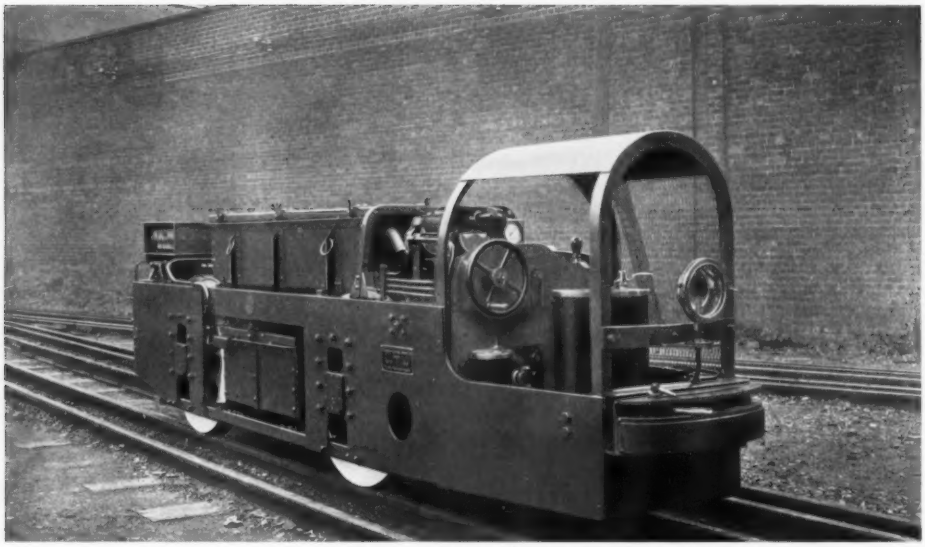


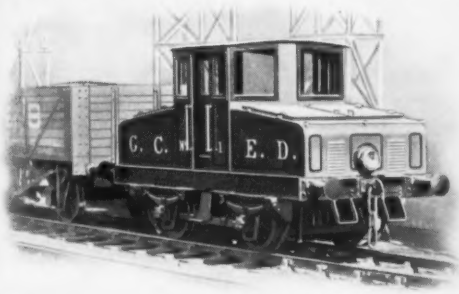
FIG. 6. A BATTERY LOCOMOTIVE ON THE TEST TRACK.

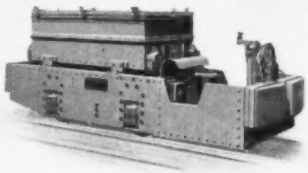
on a 2,400-volt direct-current overhead system, while the smaller unit is one of 90 automatic trucks supplied for use on the Post Office Railway in London.

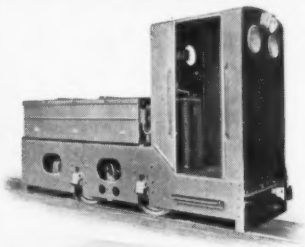
Of other rolling stock that has been tried out recently on the test track, mention may be made of battery locomotives for the General Post Office, an example of which is illustrated in Fig. 6, and for Peterborough, and a motor coach for South Africa. The latter was run for an aggregate distance of 800 miles, during which the equipment was subjected to a great number of starting and stopping operations.

It is hardly necessary to point out that the possession of a Test Track within the compass of the Works is a very great advantage indeed, both for testing standard equipments under normal or special conditions, and for trying out in practical circumstances new or modified designs.

# "English Electric"
# INDUSTRIAL LOCOMOTIVES

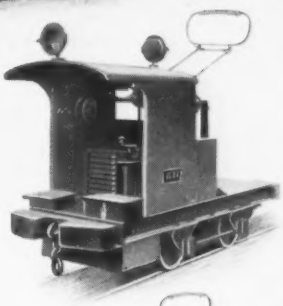


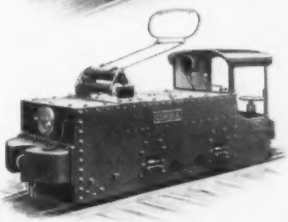


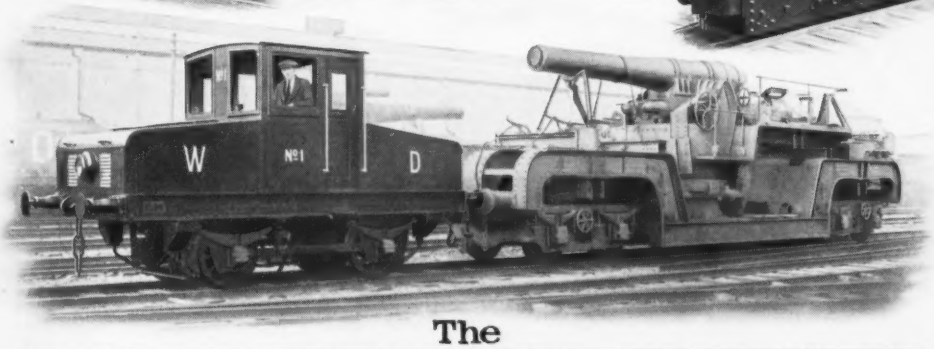


THE illustrations show a number of typical "English Electric" Industrial Locomotives for gauges of 1′ 6″ to 5′ 6″, and weighing from 2¼ to 30 tons. All sizes are manufactured for operation from a Battery, from a Trolley Wire or Third Rail, or from any combination of these.

*Write for Publication No. 305A.*





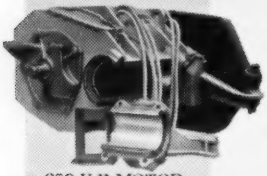



The
# ENGLISH ELECTRIC
## Company Limited.

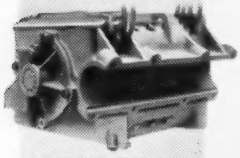
WORKS:- BRADFORD, COVENTRY, PRESTON, RUGBY, STAFFORD.
HEAD OFFICE:-
**Queen's House, Kingsway, London, W.C.2.**

"English Electric"

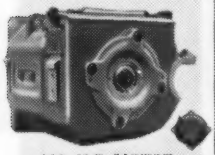
# TRACTION MOTORS AND CONTROL GEAR



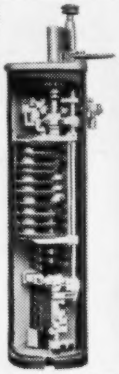
350 H.P. MOTOR, FOR STANDARD GAUGE.



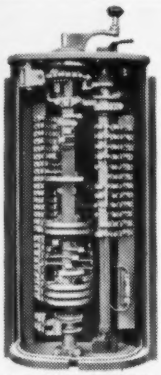
200 H.P. MOTOR, FOR STANDARD GAUGE.



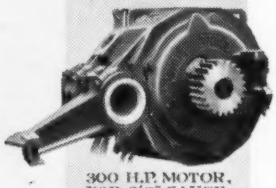
130 H.P. MOTOR, FOR 3'6" GAUGE.



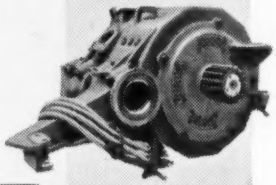
MASTER CONTROLLER FOR MOTOR COACH.



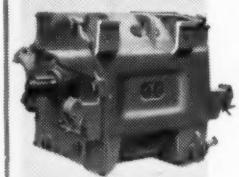
MASTER CONTROLLER FOR LOCOMOTIVE.



300 H.P. MOTOR, FOR 3'6" GAUGE.



170 H.P. MOTOR, FOR 3'6" GAUGE.



90 H.P. MOTOR, FOR METRE GAUGE.

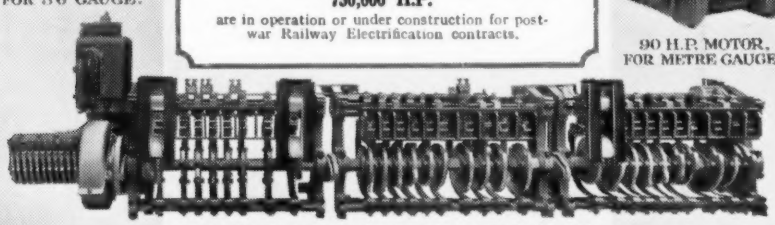
The illustrations show six of the many types of D.K. Traction Motors, built for equipments operating on all voltages from 600 to 3,000 D.C. The Camshaft Controller illustrated operates six 300-H.P. Motors on a 1,500-volt line.

**CAMSHAFT CONTROL GEAR AGGREGATING 500,000 H.P.**

**AND**

**TRACTION MOTORS AGGREGATING 750,000 H.P.**

are in operation or under construction for post-war Railway Electrification contracts.



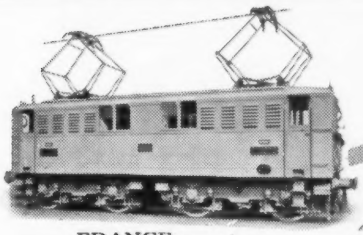
CAMSHAFT CONTROLLER FOR LOCOMOTIVE.

## The ENGLISH ELECTRIC Company Limited.

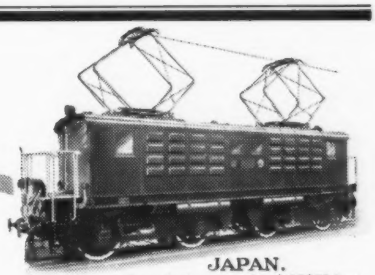
WORKS:- BRADFORD, COVENTRY, PRESTON, RUGBY, STAFFORD.
HEAD OFFICE:-
Queen's House, Kingsway, London, W.C. 2.

"English Electric"

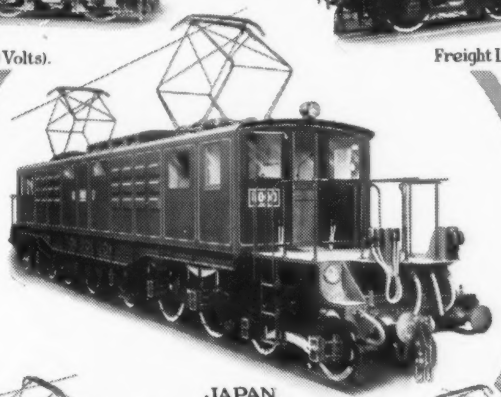
# LOCOMOTIVES



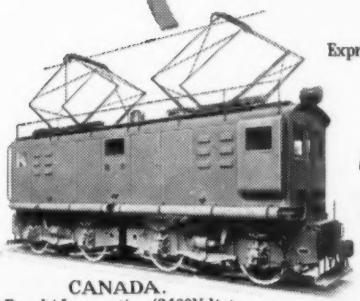
FRANCE.
Freight Locomotive (1,500 Volts).



JAPAN.
Freight Locomotive (1,500 Volts).

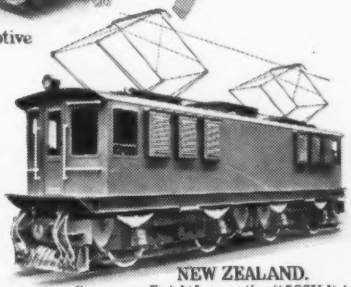


JAPAN.
Express Passenger Locomotive
(1,500 Volts).



CANADA.
Freight Locomotive (2400 Volts).

*Write for our Descriptive Publications*



NEW ZEALAND.
Passenger & Freight Locomotive (1,500 Volts).

The
## ENGLISH ELECTRIC
Company Limited.

WORKS:- BRADFORD, COVENTRY, PRESTON, RUGBY, STAFFORD.
HEAD OFFICE:-
Queen's House, Kingsway, London, W.C.2.